

The AMSAT Journal

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Editor: Joe Kasser, G3ZCZ

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Off the Pad

An Editorial

Telemetry - The Best Kept Secret

By Joe Kasser, G3ZCZ*

OSCARs send back volumes of Telemetry daily and apart from a few Command stations no one seems to be doing anything with it. We, as Radio Amateurs, tend to concentrate on the communications capabilities of the spacecraft and ignore their telemetry completely. If we do listen to a beacon, it's usually just to check that the transponder is on, heaven forbid — to actually copy any data.

The telemetry can tell us a story. It can tell us what is happening to both the spacecraft and its environment. As such it has a tremendous educational potential which has, for at least six years, remained just that — a potential.

Before every satellite launch the equations and format for the spacecraft telemetry are published by AMSAT. The telemetry tells us about the health and welfare of the spacecraft itself, and something about the payload. Spacecraft health and welfare information tells us about the battery, solar cells and onboard computer status. Payload information can range from information about transponder loading/utilization to data from instruments that measure the environment of the space in and around the satellite. Battery Telemetry is used by the command stations to determine when the spacecraft can be used, and when the transponders should be shut down. The number of individuals not associated with command stations who have decoded spacecraft telemetry and published their findings can be counted using the fingers of one hand. There's a lot of computing power out there that has the potential to process telemetry and discover something new, but does not have the access to the data.

Perhaps the reason for the lack of use of telemetry is that those who have the capability to receive the telemetry are not interested in it, and those that have the interest in it, do not have the equipment to receive it.

Does the average school science class have a computer which can be used to process telemetry data? Yes. Does the average school science class have a satellite ground

station to receive the telemetry in real time? No. So far so good. Now for the next pair of questions, why should it need to have a ground station? What has processing telemetry data have to do with receiving it in real time?

NASA's satellites in Low Earth Orbit send back telemetry data. While some scientists get a quick look at their data in real time, most of them receive telemetry tapes some time after the actual reception has taken place. There is no reason why AMSAT can't set up a repository for OSCAR telemetry data. AMSAT could then distribute data on disks to those that want it. Students could play with the data, and write or modify software to decode and examine trends. Who knows what will be discovered if a lot of people try to examine and correlate that data in different ways? It is also possible that the incentive to get the data updates faster than the distribution channels will be a driver in getting ground stations built in schools.

Are you capturing telemetry data? If you are, what are you doing with it? Are you interested in contributing to or drawing data from a telemetry data repository? For how much longer is telemetry going to remain the best kept secret of the (Radio) Amateur Space Program?

SAREX Notes Number 1

Currently scheduled for a launch next April, STS-35 is expected to carry Ron Parise, WA4SIR, and a Shuttle Amateur Radio EXperiment. Prominently featured in the SAREX will be packet radio. While being used for some dedicated experiments to be described over the coming months, the SAREX Packet Radio Terminal Node Controller (TNC) will be workable by conventionally equipped two Meter packet radio stations. The SAREX TNC will contain a ROBOT mode which will allow you to connect to it and obtain a QSO number in the "contest mode" of operation.

The SAREX will also transmit unaddressed (unconnected) packets containing messages which will contain information

of interest to all. You will see packets containing lists of calls heard and worked by the TNC in orbit.

Packet Terminal software is now smart enough to try for a connect at a predetermined time based on orbit prediction software and can even monitor the channel for the SAREX signals and automatically "attack" it by trying to connect as soon as the orbiter is heard. Given that software, and sufficient power on two Meters, it should be easy for anyone to get a connect between their ground terminal (robot) and the SAREX orbiter robot.

Now apart from the thrill of making a contact with the orbiting Space Shuttle, there isn't much else in it for most Radio Amateurs, or is there? The Shuttle flies in an orbit which allows direct contacts only to Radio Amateurs living within approximately 50 degrees north or south of the equator. If you happen to be living in that footprint, and know when the Shuttle will be in range, making a contact is not going to be too difficult. The challenge is going to be to allow stations out of direct range of the Shuttle to make a contact.

If you tune in to the packet signals on 14.105 MHz you will see many KA-Nodes and Gateways linking 20 Meters to two Meters. If the operators of these stations can set their equipment up to relay 20 Meter or any other hf band packet signals to the two Meter SAREX channel AND publicize their intentions beforehand, the SAREX experiment can be made more interesting and challenging.

Stations in Canada could then make a SAREX connect via a KA-Node in the Washington DC Area (W3EAX at the University of Maryland) when the Shuttle is in range of Washington DC. Stations in Scandinavia could do the same via a node somewhere in one of the countries around the Mediterranean Sea. Stations to the east or to the west of the Node could get a connect when the Shuttle was out of their direct range, but within range of the Node. If hf conditions were good, all sorts of links become possible.

If you have a Node than can be set up to provide this service, please let me (G3ZCZ@N4QQ) know what hf frequencies you plan to utilize, and it will be published in *The AMSAT Journal*.

Further details of the SAREX frequencies and schedules will be published in forthcoming issues of *The AMSAT Journal*.

*Editor, see page 2 for address.

"Dear Joe..."

(Letters to the Editor, G3ZCZ)

Dear Readers and Members:

Thanks to all of you who took the time to send me a packet message or wrote with suggestions and comments. It's those packet messages/letters that keep me chained to the keyboard, so if you want more Journals, keep them coming.

Seriously, this is the page where you can make your feelings known and see how the rest of the membership feel on different issues. If you have any comments on the issues raised herein, or wish to raise one of your own, then some of this column space is reserved for you. — Joe G3ZCZ@N4QQ

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CONTENTS

- 1 **Telemetry - The Best Kept Secret**
By Joe Kasser, G3ZCZ
- 1 **SAREX Notes Number 1**
By Joe Kasser, G3ZCZ
- 2 **"Dear Joe..." (Letters to the Editor)**
- 4 **Mobile and Portable Ground Stations**
By Tom Hall, N6DGK
- 5 **Getting on Frequency While Using AO-13**
By W. M. "Maury" McMahan, K4GMJ
- 6 **Getting Started with Amateur Radio Satellites**
By Joe Dzekevich, K1YOW
- 8 **Commodore 64 OSCAR Tracking System**
By John C. Koehler, N16D
- 17 **New UoSAT-OSCAR-11 Gateway Station On-line**
By Ross Forbes, WB6GFJ
- 19 **Sailing to the Moon**
By John M. Garvey, N6VHP
- 24 **Orbital Elements**
By Ralph Wallio, W0RPK

Phase 4 Fast Scan TV Transponder

Dear Joe: Is AMSAT leadership open to suggestions from the membership on Phase-4 transponder applications? I would like to see a fast scan television transponder developed for geosynchronous deployment. Benefits in the classroom (demonstrations, radio clubs, etc.) would be a great boost for our hobby and would stimulate the growth of terrestrial fast scan as well.

Operation of a fast scan transponder would require scheduling and a certain discipline among the users, but I would like to see it become a reality and even be personally involved in such a project.

As an estimate, the uplink/downlink would require between 1 and 5 Watts to a 40-dB gain umbrella for downlink and 10 Watts or less to a 40-dB gain (or better) dish for uplink. We would be dealing with a DBS type of system.

Looking five years ahead, we should consider the emerging high resolution format with multiple, cross polarized transponders to maximize spectrum conservation.

Simply keeping a geostationary platform truly geostationary for long periods is a very ambitious and sophisticated undertaking, and I am amazed that AMSAT-NA anticipates having the resources to seriously consider it. Hats off. — Bill Reid. WA4KBD@WA4ZDW

(Anyone else interested in a fast scan transponder payload for Phase-4 contact Bill. — Joe)

Geostationary MicroSat

Dear Joe: Has anyone thought of putting a MicroSat in geostationary orbit as a test of/complement to the Phase-4 satellite? At only 25 pounds, it would seem that *someone* would allow us to hitch a ride on one of their launches. — Andy WD9IYT

Terminology of Orbit Predictions

Dear Joe: I want to correct one of the assertions made both in the "Terminology" article in the last issue of the Journal and in the "Amateur Satellite Communications" column in QST, May, 1989. In both articles, statements are made indicating that atmospheric drag, i.e. collisions with air molecules, causes the velocity of the satellite to decrease. In fact, exactly the opposite is the case. Believe it or not, atmospheric drag is responsible for an increase, not a decrease, in the orbital velocity. This is the so-called "satellite paradox" which I discussed in my paper at the Sixth AMSAT Space Symposium held in Atlanta last November. That this is indeed true can be most easily seen from



the relationship between the orbital velocity (v) of a satellite in circular orbit and its geocentric radius (r) as given by the well-known expression (see Davidoff, *The Satellite Experimenter's Handbook*)

$$v^2 = GM/r$$

where G is the Universal Gravitational Constant and M is the mass of the Earth. Thus, as the orbit decays as a result of drag, i.e. r decreases, the velocity must increase because of the inverse relationship between v and r .

The reason lies in the principle of conservation of energy. As the orbital radius decreases, the potential energy of the satellite also decreases as it moves closer to the Earth. This decrease in potential energy reappears in the form of heat energy imparted to the atmosphere and to the skin of the satellite, and in an increase of the kinetic energy (energy of motion) of the satellite. It is the latter that results in the increase in the orbital velocity of the satellite.

I hope this brief explanation clears up some of the mystery. — L. C. "Doc" Emerson, W4ITJ

Dear Joe: The article that interested me most in the last issue of the *AMSAT Journal*, is "The Terminology Used in Orbital Predictions". It is excellent and should be distributed to as many amateur journals as possible.

There is one statement in that article, which I think is misleading. I have in mind the statement on top of column three, page 20: "...or the First Point of Aries because it points to the constellation of Aries." This was true more than two thousand years ago at the time of Hipparchus. Today, because of the precession, the fixed point for R.A.A.N calculations lies in the con-

stellation Pisces. But, and that is the funny thing, the zodiacal sign Aries is in the Pisces! I am sure you know all this, but I could not resist writing to you about this trifling matter, because I have seen many other authors make the same "mistake". — SM4MOT@SM6JZZ

CoCo Tapes

Dear Joe: Several months ago when I enquired during an AMSAT Net on 20 Meters about an Orbital Prediction program for the Color Computer, I was told that to the best of anyone's knowledge that one did not exist. I then obtained a listing of the W3IWI program and put it on the Color Computer 3 using a 40 column width. On page 23 of the last *Journal* I now see that AMSAT does have a program available on cassette tape for the CoCo, although I do not know if it is the 1, 2 or 3 model.

I am willing to provide a copy of my program to anyone who would like a copy if he provides me with a blank tape and enough postage to return the tape via First Class mail. I do not have a disk drive for my machine so a blank disk will be of no use. — Cliff J. Appel WB6AWM/7, P.O. Box 241, Electric City, WA 99123

Alligator Operators

Dear Joe: My problem is in two parts:

1. The inability for others to copy me while I copy myself perfectly, and
2. Why my SSB signal is much weaker than my CW signal at the same power level?

My receive station consists of two phased/power divided Cushcraft 20-element beams 45 feet high. I have, under FB circumstances, worked several European stations using as little as one Watt (one 70cm 16-element Yagi and FT 727R).

Last week I copied the beacon peaking at about S5 when the spacecraft was over West Africa and was able to hear myself perfectly well at barely S1. When I use this power level (7-12 Watts of transmitter output), other stations can't copy me until I crank up my transmitter power to bring my signal level up to the S5 level at which time I'm using about 50 Watts which I consider is too much power.

Either the problem lies with someone else's receive system or my downlink capability is too sensitive. It seems crazy to have to decrease my receive capability and increase my transmit power. In one instance there was a station from Maine booming in at S9 while I read myself comfortably at S2. Any thoughts? How many other satellite users have similar problems? — Frank MacKenzie-Lamb, NG1I.

(Your SSB signal sounds much weaker than a CW signal of equal power because the energy

is spread out over a passband of audio frequency width, 2 or 3 kHz. Whether or not you use a CW filter in the radio, your ear-mind combination have the ability to detect and read single tones better than voice or other audio that goes faster and takes up more bandwidth.

As a rule of thumb, CW is worth 10 or 12 dB or more over SSB in weak signal situations like this.

Please, don't increase your power except when it is needed to perform the communications intended. If the station you are trying to work obviously has a poor receiving setup, use your own judgment. This is regulation, good sense, and a necessity in the satellite service — Courtney, N5BF)

Contents of the Journal

Dear Joe: Here are some general thoughts about the contents of the *Journal*.

Keplerian Elements shouldn't be published, especially low-level data for UOSAT-OSCAR-9, UOSAT-OSCAR-11, MIR, SALYUT-7 and AJISAI. For the beginner, who takes the figures for granted, it's more a frustration rather than a pleasure! It isn't possible to cope with the "natural and induced" changes of these satellites within the delay from the time that the parameters were obtained to the time when they are received. There should at least be a caution that these elements must be used with care and a more up-to-date set should be obtained via packet radio.

I'm sure that you are aware of the fact that not all foreign AMSAT members can read "English" fluently. Even the beginner United States or Canadian amateur will certainly not understand all the technical terms related to satellites. I would, therefore, like to suggest a multi-lingual "Satellite Glossary" (e.g. English, German, French and Spanish) as a last page(s) attachment in the *Journal* starting with AAA and ending at ZZZ. When complete the whole collection would form a useful set of documentation.

I shall propose an International AMSAT Software Exchange at the coming "DATASPACE" convention in Surrey. There seems to be a lot of very useful software available from various AMSAT groups, but little is known about their whereabouts. If feasible, one page of the *Journal* should be reserved for the software sector, together with pertinent information and details of how to obtain the programs.

Is AMSAT-NA's policy "no advertising" in the *Journal*? If so, don't bother to read the rest of this paragraph. If not, there are some outstanding products available for the satellite operator (G3RUH, TAPR and Kansas City Tracker — just to name a few) and I'm sure that they would be willing to advertise in the *Journal*.

Naturally, "saying" is easier than "do-

(Continued on page 16)

Mobile and Portable Ground Stations

By

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If you can't put up antennas at your home QTH, you can still work DX via satellite. This article describes my experiences operating both mobile and portable (with HT's) via satellite.

A Portable QRP OSCAR Ground Station

It is possible to operate through Phase-2 LEO (low Earth orbit) satellites with small low-powered radios and simple vertical antennas. I've been doing this for some time using Mode A and operating through RS-11. The entire setup fits into a small black shoulder bag, I call "The Black Bag Portable".

The heart of this system is AEA's new 10M HT and the older Yaesu FT290R, which is the radio recently used by cosmonauts U1MIR and U2MIR. The other parts of the setup are a 10M GaAsFET preamp and a telescoping groundplane mount for the 10M antenna. The FT290R is ready to go, using the internal telescoping antenna and two Watts. The 10M HT, however, requires crystals to put its two-channel VXO in the 29.5 MHz range. AEA does not have crystals for any frequencies above 29 MHz and does not guarantee performance above 28.6 MHz. The manual does infer that a factory retune is possible but that, of course, means that the low end performance would be lost. I decided to use the GaAsFET preamp to compensate for the lack of sensitivity in the satellite sub band, hoping that the VXO would work at those frequencies.

I tackled the crystal problem with a call to Jan Crystals¹ in Florida. I've used them before as a source for "rock-bound" radios that I still have. Their service is good and the prices are reasonable. I asked them if they could make crystals for the frequencies I needed if I sent along one of the crystals I already had. AEA provides two crystals, one which sets the range of the VXO from 28.250 to 28.300 the other from 28.300 to 28.350 MHz. They assured me it was no problem, so I sent one along with my order.

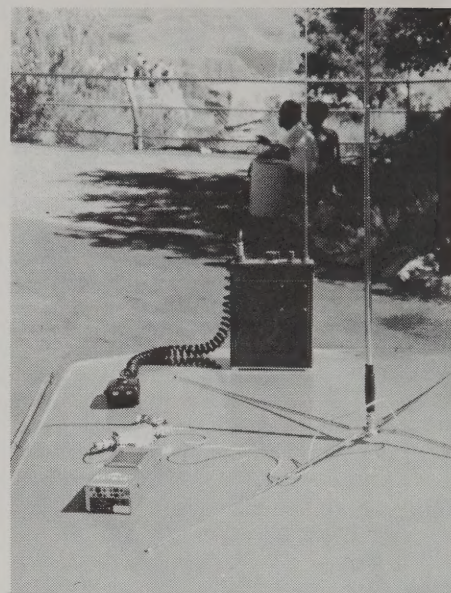
As I mentioned earlier, I thought that I would probably need a preamp to make

up for sensitivity lost at 29.500 MHz, so during the wait for the crystals I ordered and built a GaAsFET preamp. This was a Hamtronics, Inc.² Model LNW-28. These preamp kits are a great value at only \$24. There are other models that work all the way up to 500 MHz. Also during the wait I ordered crystals from AEA to make the HT work with the Hamtronics 435 MHz down converter in the mobile Mode-J station. That arrived ahead of the Jan crystals so during the next Mode-JA pass of FUJI-OSCAR-12 I gave it a try.

435.800 MHz is the bottom end of FUJI-OSCAR-12's pass band. The Hamtronics CA432-5, which is the one I am using, converts to 28.800 MHz. Since this is beyond the range of AEA's specs I had some indication of what the performance would be like at 29.500 MHz. As it turned out, even with the Hamtronics 435 GaAsFET preamp I was using and the gain of the down converter itself, I could just barely make out FUJI-OSCAR-12's beacon. The DX HT's volume control was all the way open. It definitely needed front end or i-f gain, so I installed the LNW-28 preamp. The difference was dramatic! I now had more sound from the speaker than I needed and plenty of movement from the HT's S meter. Finally, when the crystals arrived from Jan, about four weeks after the order was placed, I was ready for Mode A and RS-11.

My first try was done in the backyard using camera tripods for antenna mounts, the DX HT's telescoping antenna, an AEA half-wave portable antenna for 2M, and, of course, the LNW-28 preamp. The entire setup worked better than I anticipated. RS-11's beacon was strong, tuning the passband was not too difficult, and my uplink was coming through loud and clear. I only made one contact on this occasion with KA0SHC in Kansas. His signal was 5/9, very strong and easy to copy. He returned a 5/5 signal report for the signal coming from the FT290R.

Since then I've used the portable many times in some rather unusual circumstances. I made contact with KA4BLN in Alabama while on a tour at Griffith Observatory in Hollywood, Ca., talked to WA7NQQ in Oregon from the south rim of the Grand Canyon, and worked WW6J from the Disneyland Hotel while attending Hamcon 88. I've also made two brief contacts with WB6LLO in San Diego through FUJI-OSCAR-12 with the addition of the CA435-2 downconverter and a small



Grand Canyon, Aug. 24, 1988, 1720 UTC

432-MHz Yagi, still using just the FT290R and its telescoping vertical with two Watts of uplink power.

"The Black Bag Portable" is proof that amateur satellite ground stations need not be complicated and expensive. Operating portable does have its limitations of course, but I've found a couple of tricks to make it work.

Holding the FT290R in one hand while transmitting and rotating it in the air for strongest downlink keeps fading at a minimum. As the satellite passes it slowly spins on its axis, so rotating the two-meter antenna keeps the polarity sense the same between satellite and ground. Mounting the 10-meter antenna at a 30-degree tilt from vertical and rotating it in a 360-degree circle has the same effect. One precaution, I've also discovered that laying the 10-meter preamp along side the HT can produce rf feedback and cause the receiver to go into oscillation, so I always keep it at the top end of the radio.

For those who are interested in going portable, good luck. You're in for some real fun.

Mobile Operations on Phase-3C

Apart from working the Phase-2 satellites from the car, mobile contacts are also possible via Phase-III satellites using ordinary mobile communications equipment when the spacecraft are close to perigee. I was able to demonstrate this recently when AMSAT-OSCAR-13's Mode B transponder was left on through perigee. Having had so much success operating mobile, portable, and QRP (two watts from the FT290 using only its telescoping vertical antenna) on Phase-II LEO satellites, I knew that I could also operate Phase-III mobile if the satellite was in a suitable point in its orbit, and if the transponder was not being overloaded by high power stations.

In the past, however, the transponder was always turned off when the spacecraft approached perigee before I could hear myself in the downlink. As I discovered, down range distances less than 10 km are sufficient under normal conditions to get a readable signal. I was using my ICOM AH-32 dual-band antenna and the 100 Watts from the Mirage D1010 amplifier that I use for fringe areas of the local repeater.

My first successful QSO occurred on the morning of May 19, 1989 at 1815 UTC (MA 245 and a down range distance of 7521 km). This was with W8ZD in Ohio. I was located near work just south of Los Angeles, driving my 1987 Chevrolet Sprint that is a frequent place of Hamming these days. A recent move into a new house has only allowed me to set up a simple low-powered station. There is a total ban on outside antennas and the structure of the house and small size of the lot have made putting up even hidden antennas a difficult task.

The mobile setup consists of a single dual-band antenna coupled to two transceivers by a Comet CF-416 duplexer. The uplink transceiver is a Yaesu FT77 with a FTV707 transverter running into a Mirage D1010 amplifier providing 100 Watts into the antenna. The antenna has approximately five dB gain at 70cm and three dB at two meters. The downlink transceiver is a Yaesu FT290 hooked into a Mirage B108 amplifier using a preamp with a rated two-dB noise figure and gain of 10 dB. Nothing to boast about but enough to get the downlink to copyable level.

This setup has worked consistently during the past several passes. The total contacts now number seven, with VE4AMU in Winnipeg being the last contact this morning on the way to work (I pulled over to the side of the road). It will be interesting to see how performance improves or deteriorates over the coming days as the "bird" moves eastward (all contacts so far have been on westerly passes). Anyway, there is no question that mobile contacts via Phase-III are reliable if the transponders are on, at, or near perigee. I feel fortunate to have had the opportunity to experience this interesting mode of operation (a small consolation considering the devastation that the fixed station has suffered).

In the coming days I also hope to be on

Mode L since I now have all the equipment in the car for that. I will be using the existing transceivers together with equipment ordered from Down East Microwave (35 Watts uplink power and a loop Yagi). See you on the "bird."

References

1. Jan Crystals
P.O. Box 06017
Ft. Myers, Fl. 33906
(813)936-2397
2. Hamtronics, inc.
65 Moul Road
Hilton, N.Y. 14468-9535
(716)392-9430

Getting On Frequency While Using AMSAT-OSCAR-13 (With Precision and Without Causing QRM)

By

M. W. "Maury" McMahan, K4GMJ
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Would you like to be able to QSY to precisely the correct frequency and land on top of that DX station? Would you like to do your share to minimize the QRM caused by people trying to locate themselves? If so, read on. This article describes a simple, fast and easy procedure to determine uplink or downlink frequencies using simplified formulas.

In order to be able to pinpoint the necessary frequency, you must first determine the Doppler Shift at the current Phase (Mean Anomaly) of the orbit of the spacecraft for your particular transmitter/receiver combination. Doppler numbers from the computer tracking programs are not very accurate because they don't contain a factor to correct for the calibration errors in your equipment.

If you use the suggestions described in this article you will be able to determine your Doppler constant based on your own calibration values quickly and easily. With this value stored in the memory of a four-function calculator, you can determine the correct uplink frequency for any downlink frequency by merely entering 4 digits of the downlink and pushing the = key.

The formulas used are as follows:

DOPPLER

Rec. Freq. + Trans. Freq. - Constant(Cs) = Doppler Freq.

TRANSMIT FREQUENCY (when downlink frequency is known).

Constant(Cs) + Doppler Freq. - Rec. Freq. = Trans. Freq.

RECEIVE FREQUENCY (when uplink frequency is known).

Constant(Cs) + Doppler Freq. - Trans. Freq. = Rec. Freq.

The Constant Cs is different for each Mode of each satellite as shown:

Satellite Doppler Constants

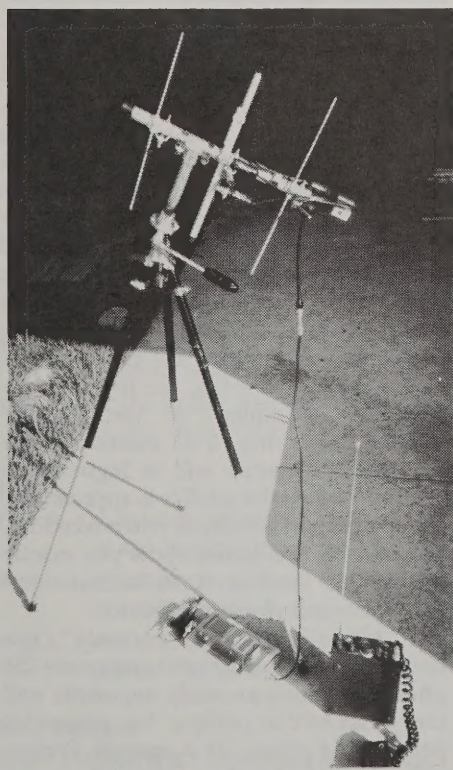
SATELLITE	MODE	Cs
AMSAT-OSCAR-13	B	1398
AMSAT-OSCAR-13	J	1413
AMSAT-OSCAR-13	L	1356
AMSAT-OSCAR-10	B	1005

NOTE: These constants only apply when the MHz portion of the uplink and downlink frequencies are *not* used.

Consider the way these formulas are used together with a four-function calculator.

You must first determine the Doppler shift at the time of operation based on your specific transmitter and receiver at the current mean anomaly. When the spacecraft is at or near apogee, the rate of change of Doppler is so small that one initial measurement value will be valid for some time after the measurement is made.

1. Select a clear frequency well away from other operators.
2. Use an uplink/downlink chart to



OSCAR-12, Mode-J. A 432-28 MHz down converter and a 432 MHz preamplifier in an aluminum box.

determine the approximate uplink frequency.

3. Transmit a tone to locate yourself, then use voice and tune the receiver for natural voice quality.

4. Write your transmitter (uplink) and receiver (downlink) frequencies down.

5. Now using just the decimal portion of the frequencies, calculate the instantaneous Doppler frequency using the formula above.

For example, the doppler frequency for a downlink frequency of 145.975.1 and an uplink frequency of 435.424.2 via the AMSAT-OSCAR-13 Mode B transponder is given by substituting the following values into the equation.

Doppler Frequency = $1398 - 975.1 - 424.2$ or 1.3

Once this value is known, the uplink frequency for a given downlink frequency can be calculated.

For example, if the downlink frequency is 145.975.1, then the uplink frequency equals $1398 + 1.3 - 975.1$ or 424.2. The full uplink frequency is 435.424.2 MHz.

During some parts of the pass, depending on your equipment the Doppler number may appear to be negative. If so, it must be subtracted and not added. All frequencies should be entered using at least three digits, thus for example 145.890 should be entered as 890.

These calculations will be accurate if the transmitter and receiver have linear frequency tracking. Absolute calibration accuracy is not needed.

Simple four-function calculators with a constant memory are cheap. It is possible to take advantage of them to simplify the number of keystrokes entered in making these calculations. The constant (Cs) can be stored in the memory, the value of the Doppler can be added to it in a second memory, then only the uplink or downlink need be entered each time the calculation is repeated. It is in fact very convenient to use two calculators, one for the Doppler and a second for uplink/downlink frequency calculations.

Use two cheap four function calculators and cut down the QRM.

or the other, but not both. I have operated both RS-10 and RS-11 at one time or another in all modes (A, K, T, KA, KT) when the satellites were being tested several months after launch, but I find Mode A my best mode.

Because RS-11 was in Mode A or KA most of the time, the engineering beacon was heard on 29.407 MHz and the Robot, when on, was heard on 29.453MHz. The Robot uplink frequencies are 145.830 MHz and 21.130 MHz. (When in Mode T or KT the beacon is on 145.907 MHz and Robot is on 145.953MHz.)

Be careful while in mode K or KA. Note that the lower portion of the passband is in the Amateur Extra sub-band.

The beacons are at 29.357 MHz and 145.857 MHz depending upon mode and the Robot is on 29.403 MHz and 145.903 MHz depending upon the mode. Note: If RS-10 is on, you will hear the engineering beacon around 29.358 -29.359 MHz or so, depending on where the satellite is as it approaches you. Also note that RS-10 can be used by Novice Class operators in Mode K and KA.

Now, let's get ready to do some operating. First of all, you have to know when the satellite is going to be within view of your station. For this, you need access to a computer. AMSAT has programs that run on various home computers and provide the Keplerian Element sets which tell the program where to start the calculations and the characteristics of the orbit.

Look at the sample computer orbit predictions shown in Fig. 3 for an RS-10/11 pass from left to right:

Azimuth and Elevation are given if you have beams to direct. In the case of RS-10/11, the transponders are *NON*-inverting. This means that USB signals on the high end of the uplink come through as USB signals on the high end of the downlink. This is the worse case for Doppler shifting because the Doppler *adds* for both links. As the satellite approaches you, it can be thought of as compressing or pushing frequency, so the Doppler is positive. When the satellite is overhead, the Doppler is zero for a few moments and as the satellite recedes, the frequency is stretched or pulled, so the Doppler number is negative. This means that for RS-10/11 the beacon will be higher than you think when the satellite is approaching and lower than you think when receding. The remaining columns show you exactly where the satellite is in latitude and longitude and phase numbers.

A "phase", or "mean anomaly", is a unit of reference. Each orbit comprises 256 phases or mean anomaly segments and they reset to 0 at perigee. So, phase 0 is perigee and phase 128 is apogee. Perigee is the closest point of the orbit to Earth and apogee is the farthest point of the orbit to Earth.

Getting Started with Amateur Radio Satellites

By

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Not all satellites require expensive equipment, low-noise uhf transverters and directional antennas with azimuth and elevation rotors which all can add up to a major investment. If the satellite is in low Earth orbit, and if you own a 2-meter SSB/CW and low band rig or two low band rigs (one transceiver and one receiver) plus some simple omni-directional antennas and/or dipoles, you are in business.

These satellites are known as Phase-2 spacecraft for historical reasons.

RS-10/11 is such a satellite. RS-10/11 is actually two Amateur Radio packages riding on the same platform as Soviet COSMOS 1861. COSMOS 1861, a Soviet version of our SARSAT (Search and Rescue Satellites) is in a near circular orbit approximately 1,000 km (600+ miles) above the Earth's surface.

The characteristics of the RS-10/11 Satellites are shown in Fig. 1.

RS-10/11 has several advantages for newcomers to satellites because of its low circular orbit. These advantages are:

- Simple equipment: usually existing equipment already in the shack

- Simple antenna systems: omni-directional and/or dipoles.

The disadvantages of RS-10/11 are:

- Maximum Doppler shift - harder tuning

- Ionospheric absorption and reflection on 29 MHz - path loss

- Short time window for QSOs.

Because RS-10/11 requires only a modest investment, and in most cases no incremental investment, RS-10/11 makes an ideal beginners satellite. Once one becomes adept at making QSOs through RS-10/11, however, there is a challenge to try to work special situations such as QSOs through several satellites; via Aurora; transatlantic QSOs and experiments with E-layer propagation effects.

Before starting a pass, you have to listen to the lower engineering beacon to see which satellite is operating, RS-10 or RS-11. The RS-10/11 transponder frequencies are shown in Fig. 2. Listen 1.5 - 2 kHz above the lower beacon frequencies to take into account the Doppler shift. For most of 1988, RS-11 was operating, but at the time of writing, as we enter 1989, RS-10 has been active. You will hear one package

Fig. 1 — The characteristics of the RS-10/11 Satellites

Antenna Req.	Omni-directional/dipoles
Pass Time	10-25 minutes/pass
Transponder	Linear & Robot
Doppler	High
Modes	A, K, T, KT, KA
Transponder	40 kHz Wide

The phase numbers are not that important for RS-10/11 because the satellite remains in the same mode for its entire orbit. For OSCAR-13, however, because the window is visible for so long, the satellite will be switched between modes depending upon the phase, (mean anomaly) number.

I use the following station configuration for my RS-10/11 operations:

- Kenwood TR-9130 for Mode A up, 25 Watts with Big Wheel Antenna (3 - 1/2 wave loops)

- Kenwood R-2000 into a dipole

Now, if you want to make hearing the downlink easier, use a 10-meter pre-amp and if you want to work the satellite low on the horizon, use a 100 Watt amp. However, you do not need them to make contacts, and in no case use a 100 W amp into a beam on 2 Meters — it's just too much ERP. The RS-10/11 passbands are split into 4 kHz segments. If your signal is too strong, you will only hurt the users, and yourself, within your 4 kHz segment.

My alternative station configuration is:

- Kenwood TS-830S for Mode K and KT up, 100 Watts into a dipole

Fig. 2 — RS Transponder Frequencies:

RS-10

Mode A:	145.860-145.900 MHz up yields 29.360-29.400 MHz down
Mode K:	21.160-21.200 MHz up yields 29.360-29.400 MHz down
Mode T:	21.160-21.200 MHz up yields 145.860-145.900 MHz down

RS-11

Mode A:	145.910-145.950 MHz up yields 29.410-29.450 MHz down
Mode K:	21.210-21.250 MHz up yields 29.410-29.450 MHz down
Mode T:	21.210-21.250 MHz up yields 145.910-145.950 MHz down

Both Packages

Mode KT:	Mode K & T Combined (15 Meters up, 2 & 10 Meters down)
Mode KA:	Mode K & A Combined (15 & 2 Meters up, 10 Meters down)

- Kenwood R-2000 (Mode T, KT) or Kenwood TR-9130 (Mode A, KA) and dipole for Mode K and Big Wheel for Mode T and KT.

A good alternative to the Big Wheel is a crossed pair of dipoles mounted above a ground plane. See "turnstile" antennas in the ARRL satellite and antenna handbooks for reference. Note that these types of antennas are only good for low Earth orbiting satellites like RS-10/11.

Now back to operating:

First listen for the lower engineering beacon from the previous listed frequencies. Because of Doppler effects, the beacon will be slightly higher by .5-1.0 kHz than the actual frequency.

As the beacon becomes louder, try tuning around in the passband. SSB signals will be on the high end and CW signals will be on the low end, with both modes mixed in the middle. (Editor's note: This conforms to the Satellite Passband Band plan first proposed by Pat Gowen, G3IOR, and Joe Kasser, G3ZCZ/W3, in *The AMSAT Newsletter*, Volume IX Number 3, September 1977.)

Note the Doppler shift. As you keep the receiver tuned to one frequency, the signals will drift. You, in effect, have to track the signal with your receiver in order to stay tuned on the signal. At first, just try doing some SWling on several passes. Get used to the Doppler and try copying the lower engineering beacon or listen to stations QSOing the Robot on the upper beacon, if it is on.

Once you have your courage up, and you refer to your orbit calculations, select a high pass — a pass of at least 40 degrees above your horizon. This will ensure that you will have enough time to find yourself for the first time and that your signal will be fairly strong due to the satellite's proximity. Now select an open spot in the downlink band. Your strategy for your first contact will be to find a hole; find your signal and place it into the hole; call CQ and then let the more experienced operators find you.

For this example, let's say you are in mode A or K and that you select 29.440 MHz as the open frequency or hole. Tune your receiver to 29.440 MHz and place your transmitter on 21.240 MHz (Mode K) or 145.940 MHz (Mode A). Now, while moving your transmit frequency ± 5 kHz while hitting a series of dits, you should hear your signal go through 29.440 MHz.

Depending on where the satellite is, you can be up to 4 kHz above or below where you think you should be.

Now call CQ. Use a contest type format something like: CQRS CQRS CQRS DE K1YOW K1YOW AR. I call CQRS because not everyone on 15 Meters is working the satellite, so you will hear stations coming through the 15-Meter uplink who are only listening to 15 Meters (you do not have

this problem when the satellite is only in mode A or when 15 Meters is not open). The "RS" helps the satellite folks find each other.

You are operating full duplex, so wear headphones to prevent SSB feedback or to block the side-tone from your uplink transmitter. While you are calling CQRS, you may hear another station zero — beat your signal. In that case, just finish the CQ and K. If he does not answer, do a quick ?? DE K1YOW K.

Because the satellite pass time is short, a QSO on CW may look like: CQRS CQRS CQRS DE K1YOW K1YOW AR.....K1YOW K1YOW DE N8AM N8AM KN.....N8AM DE K1YOW TNX UR RST 559 559 IN MASS MASS NAME IS JOE JOE BK.....BK QSL JOE UR RST IS 559 559 IN OH OH NAME IS TOM TOM BK.....BK QSL TOM GUD LUCK TNX AND 73 73 N8AM DE K1YOW SK.

During the above exchange you are going to wish that you had another hand. While you are transmitting you are going to have to adjust your TRANSMIT frequency to try to hold yourself on frequency as the Doppler shift moves your signal. One point to remember: moving your transmit frequency helps but you won't be exactly on frequency with the other station. Because you each are at different points on the Earth you each have a different range to the satellite and you each will have a slightly different Doppler shift rate.

When giving signal reports, I use a relative signal report, much like you would use on a repeater system. Any signal heard as strong as the beacon I give a 5-8 or 5-9. It is much like saying "full quieting" through a repeater. Most signal reports are around 5-3 to 5-7 range. (Editor's note: See *Meaningful Signal Reports*, *The AMSAT Journal*, Volume 12 Number 1, May 1989 for an alternative.)

One hint for your first QSO: start with a CW contact first because CW is easier to copy as the Doppler shift moves your signal. SSB is much more critical and you have to keep your signal in tighter check.

Here are some hints that will make your satellite work a little easier:

- Listen several minutes before a pass starts. You will hear the beacon below your horizon in many cases (if it changes mode, the beacons will help you find what mode it is in).

- Use omni-directional antennas so you do not have to worry about tracking a fast moving, low orbiting satellite. Use dipoles for 21 and 29 MHz and a vertical or turnstile for 2 Meters. (The vertical will work better for low passes and the turnstile for all passes. A 2-Meter beam can be used, but unless you have an elevation motor, only low passes will be best.)

- On CW use a hand key. It helps to be able to continue sending if you lose your

signal on the downlink because of a polarization fade. Sometimes you can't hear your signal but that does not mean the other station has lost you.

- A 10-Meter pre-amp, like ones that ARR sell, make it a lot easier to copy. Many receivers are not that hot at 29.4 MHz. However, remember that you may overload the 10-meter pre-amp when in Mode K due to your 15-meter transmitter being near your 10-meter receiver.

- 25 Watts on 2 Meters or 100 Watts on 15 Meters is all you need for power.

- To work the Robot (auto-transponder), call it in the format of: RS11 DE K1YOW AR and use an electronic keyer and send at 20-25 wpm. If the robot understands you, it will return your call and give you a QSO serial number. In addition, you will be able to hear your signal repeated on the upper beacon when you are correctly sending on the Robot's uplink frequency. The same Doppler rules apply

to working the Robot. Try to hold your transmit frequency inside of the Robot uplink passband.

- Watch that Doppler. On approach, your signal may be 1-4 kHz below where you think. Adjust your transmitter 1-4 kHz below your desired operating frequency and move around to find yourself in the downlink. If you have a long QSO, the Doppler will stop for an instant at the peak and reverse, and then you'll have to chase your signal in the other direction.

- Most of your contacts on high passes will be like short haul E skip. However, on low marginal passes, you can make some longer contacts.

So, good luck in getting started with Amateur Radio satellites. As for this year's planned activities, the Soviets should launch RS-12/13 on another COSMOS satellite platform and AMSAT will launch 4 MicroSats, so there is plenty of satellite activity planned for the future.

Fig. 3 — Sample Computer Generated Orbit Predictions

K1YOW: Lat = 42.500
 Long = 71.500
 Ht = 50 m
 Window limit = 0.0 deg
 Element Set 13: RS-10/11 (OJB
 18129 Set: 113)

Doppler shift calculated for 175.300 MHz

Current Arg Perigee: 149.6581

R.A.A.N.: 97.6739

Period: 104.9637

S.M.A.: 7370.839

Eqx Time: 2337:32

Eqx Long: 229.2

U.T.C. HHMM:SS	AZ deg	EL deg	DOPPLER hz	RANGE km	HEIGHT km	LAT N+S	LONG W+E	PHASE <256>
8/24/88	WED							
0008:00	354	-1.7	3641	3915	987	74.0	82.5	224
0010:00	357	5.3	3621	3172	986	67.6	74.9	229
0012:00	1	14	3508	2444	985	61.1	70.8	234
0014:00	9	28	3167	1768	985	54.4	68.3	239
0016:00	31	50	2163	1250	984	47.5	66.7	243
0018:00	106	58	-477	1142	984	40.9	65.5	248
0020:00	145	35	-3144	1536	984	34.1	64.7	253
0022:00	156	19	-3685	2172	984	27.3	64.0	2
0024:00	160	8.1	-3690	2889	984	20.5	63.5	7
0026:00	163	0.4	-3688	3632	984	13.7	63.1	12

Time and date are in UTC.

Commodore 64 OSCAR Tracking System

By
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Are you tired of adjusting the position of your satellite antennas every few minutes during a low orbit satellite pass? Do you not seem to have enough hands for adequate operation of your station during rapid-fire satellite QSO's? If the continual update of antenna positioning interferes with your OSCAR contacts then why not build a reliable and inexpensive tracking system for hands free rotor control of OSCAR antennas.

Described here is an automatic tracking system, designed for the Commodore 64 computer, Alliance HD-73 rotor, and U-110 rotor.

System Requirements

1. C64 computer with disk drive.
2. C-64 OSCAR Tracking Interface (Described later in this article).
3. HD-73 and U-110 rotors and controllers. (Control box modifications are necessary.)
4. 5V + DC 1-Ampere regulated Power Supply.
5. C64 SUPERTRAKPLUS software. (Available from the AMSAT software ex-

change. Write to AMSAT Hq., 850 Sligo Ave., Silver Spring, MD 20910)

Scope of the Project

The heart of this OSCAR tracking system is the "Interface". The interface links two antenna controllers (HD-73 and U-110) to the Commodore 64 and is controlled by MAPTRAKPLUS software, a part of the C64 SUPERTRAKPLUS software.

MAPTRAKPLUS tracks simultaneously, in real time, the position of up to eight satellites and updates their position on a world map display on the C64 monitor. However, only one of these eight satellites can be physically tracked with the HD-73 and U-110 rotors in real time.

The SUPERTRAKPLUS package contains all the necessary calibration and test software to support the tracking system. The control software takes advantage of the dual speed capability of the HD-73 motor to start the motor slowly at the beginning of a azimuth rotation, speed up the motor in the middle of a rotation, and slow the motor down as the antenna's position approaches the desired bearing.

Construction of the tracking system consists of building the OSCAR tracking in-



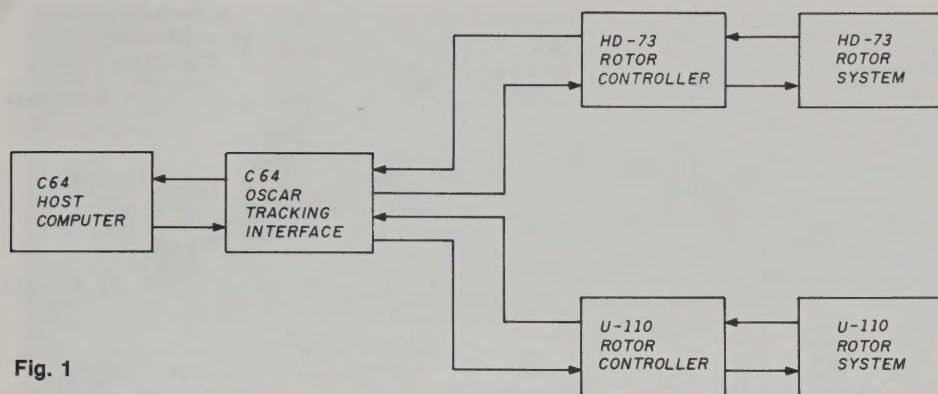


Fig. 1

interface, modifying the HD-73 rotor and controller, and building the U-110 controller. Furthermore, the existing feedback potentiometer within the HD-73 motor housing should be replaced by a precision servo potentiometer. An external elevation feedback potentiometer must be mounted on the antenna array's horizontal fiberglass boom also. When properly calibrated, the tracking system is capable of accuracy to ± 5 degrees for both the elevation and azimuth rotors. Accuracy in this case is dependent upon A/D Converter error, feedback potentiometer precision, and the eight-bit representation error in converting a 0-360 degree value to binary value in the range 0-255. Although this project is detailed and time consuming, at the end of it, you will be rewarded with a reliable, accurate automatic tracking system suitable for most amateur satellite communications purposes. As a final note, most parts are available from either Radio Shack or Jameco Electronics.

Circuit Description

Block diagrams of the C64 OSCAR Tracking System are shown in Figs. 1 and 2. The tracking interface contains two main sections: 1) the motor control section, and 2) the antenna position feedback section.

Motor Control Section

TTL level control data is sent in a eight-bit parallel format from the C64 to the octal latch 74LS373 where it is stored temporarily (latched). Parallel data lines PB0-PB5 control the state of the motor relays and PB6 and PB7 control the logic state of the 4066 analog switch and the A/D converter enable line, respectively. Each of the six motor relay control lines from the output of the octal latch are inverted as the latch's outputs on interface power-up are high. The inverter simply assures that none of the relays turn on when power is applied to the tracking interface. Each relay control line contains an LED (light emitting diode) to indicate that a motor control relay is switched on or off. Six relays are needed to rotate the HD-73 right and left (CW and CCW) at both rotor speeds and

to rotate the U-110 motor up and down. The MAPTRAKPLUS control software will only switch one relay on at a time. Diodes D7-D12 are wired parallel to the relay coils to dampen inductive spikes which occur when the relay-coil field collapses.

Antenna Position Feedback Section

Mechanical Details:

Without a means of antenna position feedback information, the SUPERTRAKPLUS software is "blind" as to the actual azimuth and elevation of the OSCAR antennas. Both the elevation and azimuth rotor systems contain a feedback potentiometer that is indirectly attached to the rotor's motor shaft. When the motor rotates so does the potentiometer shaft. In the case of the HD-73 motor, the feedback potentiometer is located within the rotor housing. This potentiometer must be replaced with a precision servo potentiometer (Spectrol model 132-0-0-501). The potentiometer exchange is necessary since the original potentiometer is noisy and has

low resolution. The U-110 elevation rotor's feedback system is slightly different. The feedback potentiometer (a surplus instrumentation model) is mounted outside of the elevation rotor and is attached to a bracket mounted on the horizontal fiberglass boom. A weighted arm consisting of an eight-inch hollow square metal tube with several bolts or lead weights mounted at the suspended end is attached to the shaft of this potentiometer. When the horizontal boom is rotated up or down, the potentiometer's shaft remains in one location because of the weighted metal arm attached to the shaft.

Electrical Details:

The digital electronic circuitry is shown in Figs. 3 and 4.

The analog feedback voltage from both potentiometers must be converted to a digital form for the C64 to interpret the antenna's position. The feedback voltage from the HD-73's feedback potentiometer varies from 0-5 volts which corresponds with a complete revolution of the potentiometer shaft of 0-359 degrees of azimuth revolution. Likewise, the elevation rotor potentiometer feedback voltage varies from 0 to approximately 1.25 volts which corresponds to 0-90 degrees of elevation (assuming a single turn feedback potentiometer is used).

Within the interface, both potentiometer feedback voltages are fed through individual low-pass filters to two inputs of an analog bilateral switch (4066). The logic state of pin 16 of the octal latch (74LS373) determines which potentiometer voltage is to be selected by the analog bilateral switch. The outputs of the analog switch are connected together in parallel and the

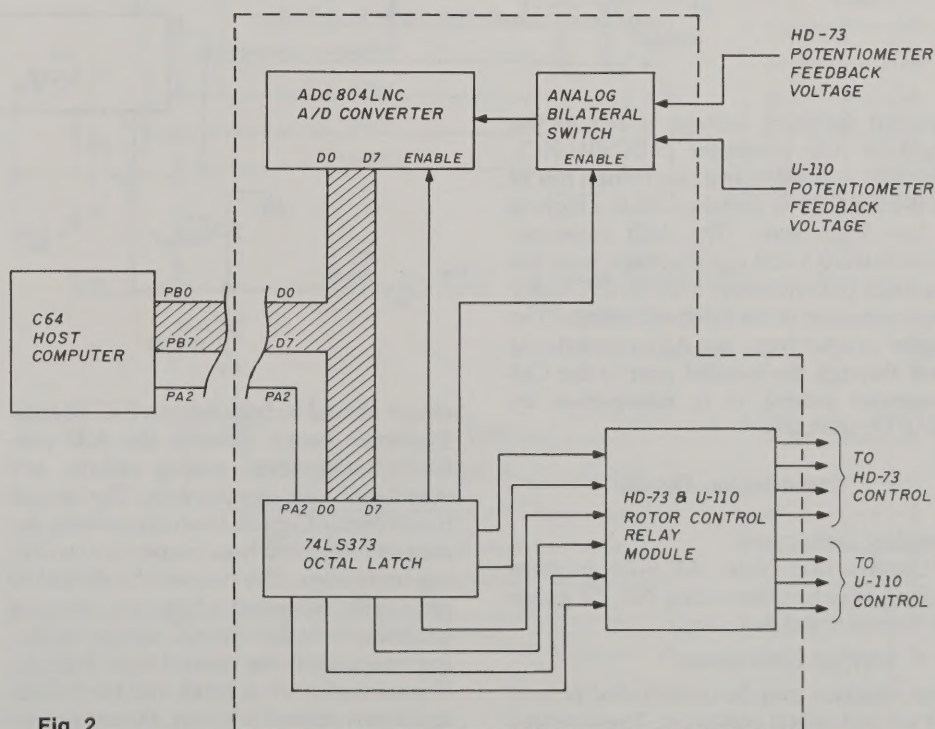


Fig. 2

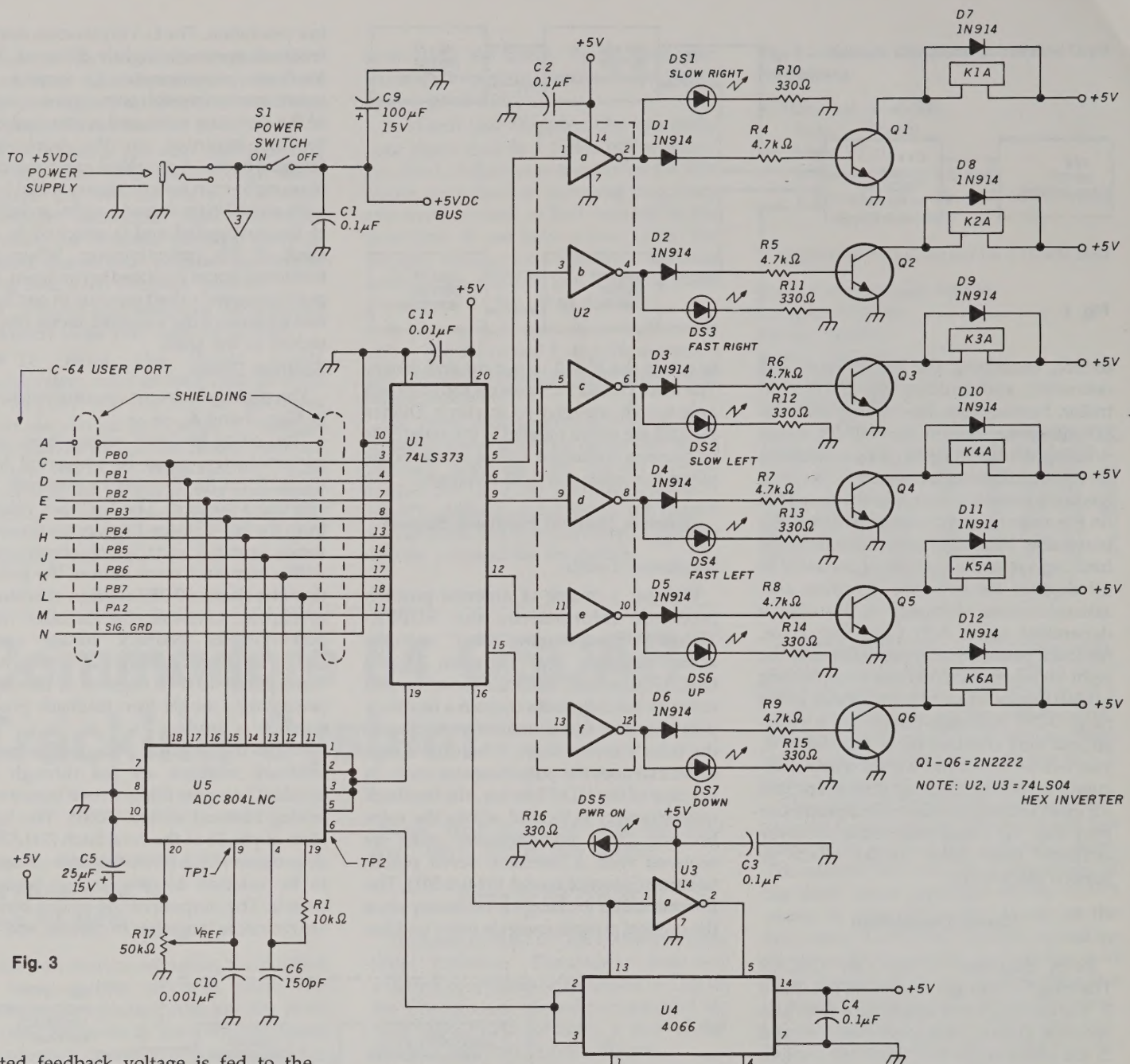


Fig. 3

selected feedback voltage is fed to the eight-bit A/D converter (ADC804LNC). The A/D is enabled and reset when pin 19 of the 74LS373 is switched from a high to a low logic state. The A/D converter converts the 0-5 volt input voltage from the feedback potentiometer to a 0 to 255 binary representation of the feedback voltage. The digital output from the A/D converter is sent through the parallel port to the C64 computer where it is interpreted by MAPTRAKPLUS.

Construction Details

Building Instructions:

Construction Note: All point-to-point wiring may be done using No. 22 gauge or thicker insulated wire.

1. Interface Construction:

The interface may be constructed in an 8 x 7 x 2-inch metal enclosure. The interface

circuit should be built on two P.C. boards. The main board contains the A/D converter, octal latch, analog switch, and associated logic components. The second board (Relay Control Module) contains the control relays and their respective switching transistors. The two boards should be physically separated within the interface enclosure to isolate the AC voltage switching relays from the control logic module. If your enclosure is small and the boards are closely spaced together, mount a metal

partition between the boards for shielding purposes. Drill wiring feedthrough holes as necessary and construct a grounded aluminum foil shield over the relays as shown in the photograph on page 13.

2. U-110 Controller Construction:

The elevation rotor controller unit shown in Figs. 5 and 6 may be enclosed in a 6 x 5 x 4-inch metal box. Parts such as the transformer and the 155 μ F capacitor can be salvaged from the original U-110 con-



trol box. Wiring can be done point-to-point and using two five-lug tie points for common connections. The center lug of both five-lug tie points should be mounted to the inside of the chassis bottom at central wiring locations. Mount the eight position feedthrough barrier strip on the back of the controller unit such that none of the eight feedthrough pins touch the metal chassis. The six-pin female moxex connector should be mounted and glued with epoxy to secure it to the chassis.

3. HD-73 Controller Modifications:

The HD-73 Controller is shown in Figs. 7 and 8.

Prepare seven 8-inch insulated No. 18 gauge wires for the HD-73 modifications. Expose $\frac{1}{4}$ -inch of bare wire at either end of these seven wires.

a. Remove the black plastic back of the HD-73 controller unit by removing the two hexagonal head machine screws located on the bottom of the controller. Store the screws in a safe place so they won't get lost.

b. Mount a nine-pin female moxex connector to the upper left hand corner of the back of the plastic controller housing (See Fig. 8). This procedure is achieved by drilling a 9/16-inch hole 1 inch by 1 inch from the upper left hand corner of the housing and enlarging the hole with a small steel file to match the square shape of the connector. After the connector is installed, apply a liberal amount of epoxy to the housing around the perimeter of the hole to secure the connector to the housing.

c. **IMPORTANT:** At this point either replace the two-conductor AC input power cord with a three-conductor cord (AC-GRD-AC) or expect to ground the metal chassis of the controller unit to a solid Earth ground. Solder one lead of a 0.001 μ F (250V) disk capacitor to the (hot) AC input line of the controller unit (See Fig. 7). Solder the other lead to ground. Repeat

this process for the (neutral) AC input line.

d. Replace the existing calibration potentiometer (300-ohm) with a 10k-ohm linear potentiometer. Make certain the two wires

leading to the potentiometer are attached to the same terminals of the new potentiometer upon resoldering.

e. Solder one lead of a 0.1 μ F (50V) disk capacitor to pin six of the inside lead of the controller unit's screw terminal. Solder the other lead to pin four (ground) of the screw terminal. Make certain there isn't any chance for the uninsulated lead to touch any exposed wires. Suggestion: Slide an unused insulation sleeve from a scrap wire of similar diameter on to the capacitor lead soldered to pin six of the screw terminal. In the same manner, solder one lead of another 0.1 μ F (50V) disk capacitor to pin one of the screw terminal. Insulate this lead as described before. Ground the other lead of the capacitor to pin four of the screw terminal.

Use the prepared eight-inch wires for the following procedure:

f. Cut the wire leading from the junction of the 83-ohm and 18-ohm resistors to pin five of the screw terminal. Replace it with an insulated wire from pin five of the screw terminal to pin six of the nine-pin moxex

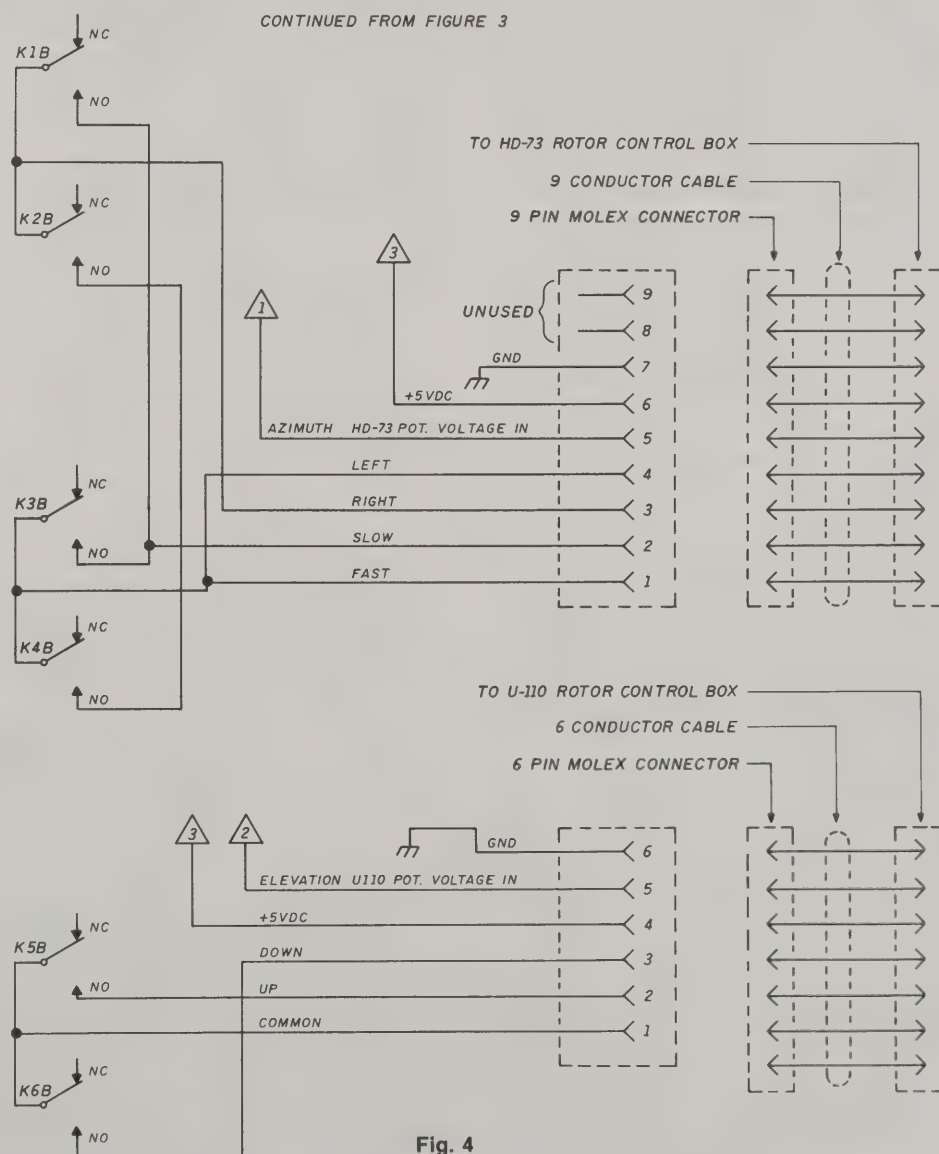


Fig. 4

connector. Solder an insulated ground wire from pin four of the screw terminal to pin seven of the molex connector. Solder a wire from pin two of the screw terminal to pin five of the molex connector.

g. Solder an insulated wire (No. 18 gauge) from pin one of the screw terminal to pin four of the molex connector. Similarly solder a wire from pin six of the screw terminal to pin three of the molex connector.

h. With the front panel of the controller unit facing towards you, look down from above at the large rocker switch (located on the inside front panel). Solder one end of an insulated wire to the top spade lug on the right hand side of the switch. Solder the other end of this wire to pin one of the molex connector. Solder a wire to the largest triangular shaped etch pattern on the small P.C. board located near the transformer (as a reference, the lead from the banded end of the three-ampere diode is wired to this etch pattern). Solder the other end of the wire to pin two of the molex connector.

i. Solder one end of a $0.01\ \mu\text{F}$ (25V) disk capacitor to pin two of the screw terminal. Solder the other end to pin three (ground) of the screw terminal.

j. Bind the wires from the molex connector with a few cable ties or electrical tape to reduce wire clutter.

k. Reassemble the HD-73 housing to the controller unit being careful not to damage

any of the control wires in the process of reassembly. Secure the housing to the base unit by screwing the two hexagonal head machine screws into their sockets.

Cable Construction:

Cables Required:

a. (6 foot) six line Interface to U-110 Controller Unit cable.

b. (6 foot) nine line Interface to HD-73 Controller Unit cable.

c. (5 foot) 10 line C64 to Interface cable.

a and b: Both cables should be constructed with No. 22 gauge or thicker insulated wire surrounded by a shield. Terminate the ends of the cable with the appropriate male molex connectors and be sure to verify each line for continuity. The connectors should match pin for pin at each end of the cable. Wrap electrical tape around the cable and connector to strengthen the cable-connector junction.

c: Construct the insulated shielded parallel communications cable using a male DB-25 connector w/ hood, 22-pin edge card connector, and five-foot ribbon cable. Wrap aluminum foil around the cable along its entire length and ground both ends of the shield. Wrap ordinary electrical tape around the foil at regular intervals to hold it in place.

System Testing and Calibration

1. Connect your C64 to the tracking interface via the 10-line parallel cable.

2. Turn on the C64 computer.

3. Turn on the 5V + DC 1-ampere power supply.

4. Turn on the tracking interface.

At this point the interface's "power on" LED should be lit. If any of the other LEDs are lit, immediately turn off the interface and turn it back on to reset the interfaces logic. If the problem still exists, troubleshoot as follows:

a. Is the C64 turned on?

b. Is the parallel cable properly wired? Check the schematic.

c. Check the interfaces wiring, especially the wires leading to the LEDs.

When all seems to be working, LOAD and RUN "RLY/LED TST", 8. Follow the instructions given in the program. Press the function keys F1 to F6 to check if each LED (light-emitting diode) on the interfaces front panel matches the control function displayed on the C64 screen. For example, by pressing function key F5 the elevation "up" LED should light. If the LED does not light according to the control function key pressed, or does not light at all, recheck the wires leading to the LED. One of the six relays will be activated simultaneously with a LED after a function key is pressed. You should hear a audible "click" when a relay is activated or deactivated. If a relay does not activate after a control function key is pressed, check the wires leading to the relay coil. Although it is difficult to verify aurally which of the six relays is being activated after a function key is pressed (because of the close spacing between relays) this is not a concern. We simply want to confirm that the correct LED and a relay are being activated upon pressing a control function key. The control relays will be tested later.

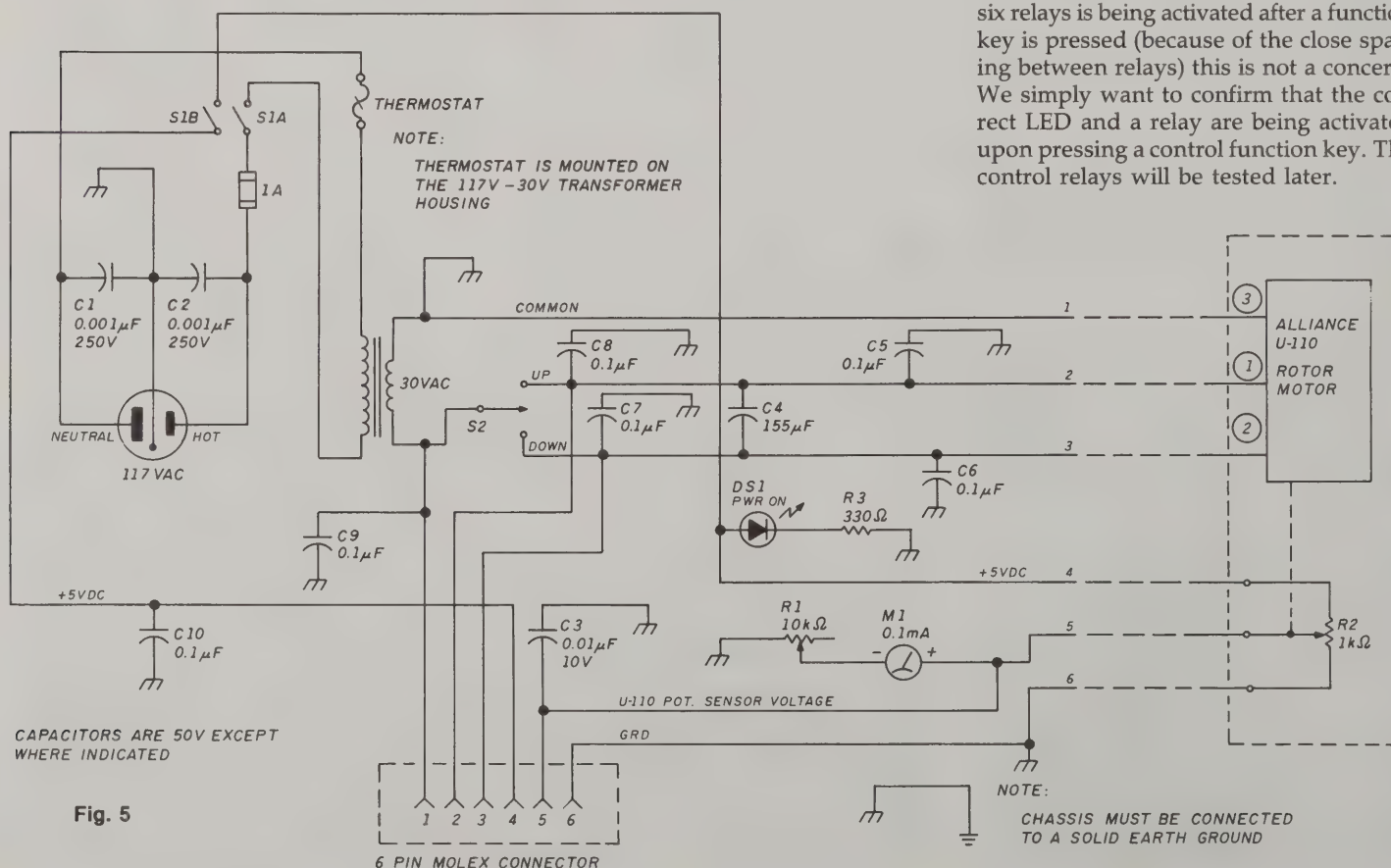
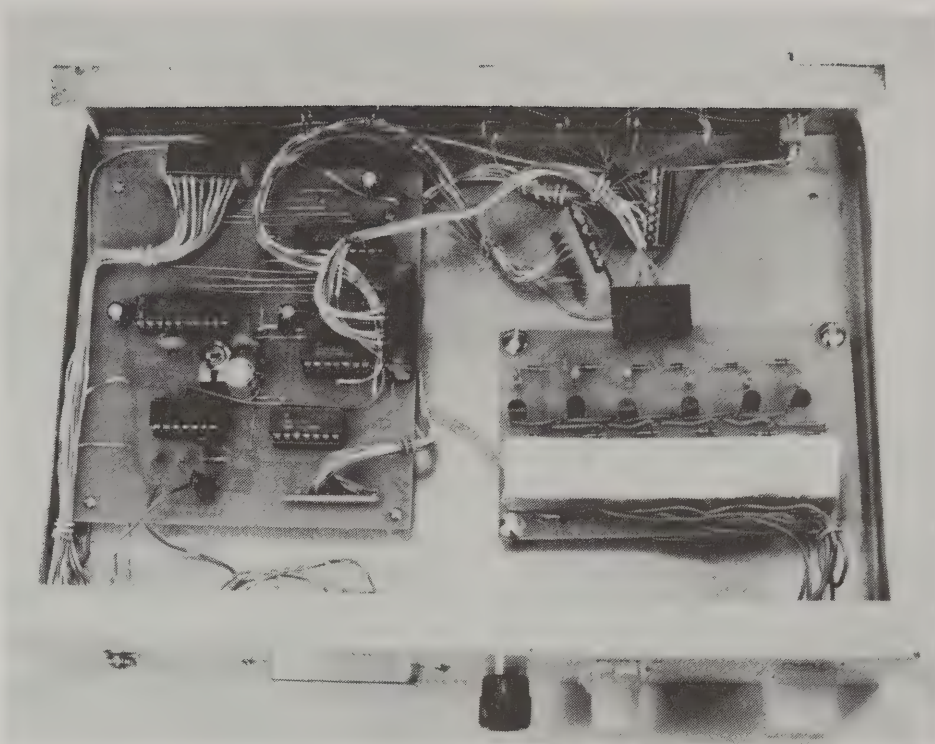


Fig. 5

A/D Converter Testing:

Note: A variable DC voltage generator used for A/D testing purposes can be constructed as shown in Figure 10.

LOAD and RUN "A/D TEST", 8. Follow the instructions given by the program. Feed a 5.0 V DC voltage into pin 5 of the nine-pin molex connector mounted on the back of the interface. While glancing at the AZIMUTH RAW DATA displayed on the C64 monitor, adjust the 50K-ohm trim potentiometer located on the main control board such that the AZ. RAW DATA display is flickering between 254 and 255. Note: The voltage at TP1 (see Fig. 3) should read about 2.5 V DC. Next, using the variable DC voltage generator, feed various voltages from 0 to 5 V DC into pin five of the nine-pin molex connector. At the same time, glance at the AZIMUTH RAW DATA values displayed on the C64 screen and notice that as the input voltages are increased, the A/D voltages also increase in value. Likewise, as the input voltages decrease, the RAW A/D DATA values should also decrease. A 0V input should correspond to a AZ. A/D value of 0. Similarly, a 5-V DC input value should correspond with a AZ. A/D value of 254-255. The A/D converter has now been tested.



Rotor Calibration Procedure:

Note: Calibration tests should be done inside your shack next to your computer.

When testing and calibrating the elevation feedback system, the rotor assembly should be mounted on a suitably strong test rig and assembled as shown in Fig. 9. The antennas should not be mounted on the horizontal elevation boom at this time.

HD-73 Rotor Modifications and Calibration:

IMPORTANT! Both the HD-73 and U-110 Controller should be plugged into a separate grounded wall socket than the outlet that the computer and interface power supply use. This is necessary to eliminate AC coupling from the controllers to the computer and interface.

Reference No. two describes motor disassembly and potentiometer replacement instructions. Copies of this reference are available from QST or from the author for a nominal fee (50 cents + S.A.S.E.).

It is not necessary to grind down the stop bar as instructed in Reference No. two.

Install a precision servo potentiometer (Spectrol model 132-0-0-501) 500-ohm instead of the original potentiometer located in the motor housing. The potentiometer exchange is necessary because the original potentiometer is noisy and low in resolution which results in decreased and compromised antenna positioning accuracy. During potentiometer replacement and calibration, loosely tighten down the bolts holding the rotor motor housing together as the housing will have to be opened a number of times for calibration readjustment. Take care not to spill any of the ball bearings on the floor during this operation.

Turn on the C64 and load "CALIB TST", 8. Run this program. Turn on the 5V+ DC power supply, tracking interface, and HD-73 rotor controller. After the replacement servo potentiometer is

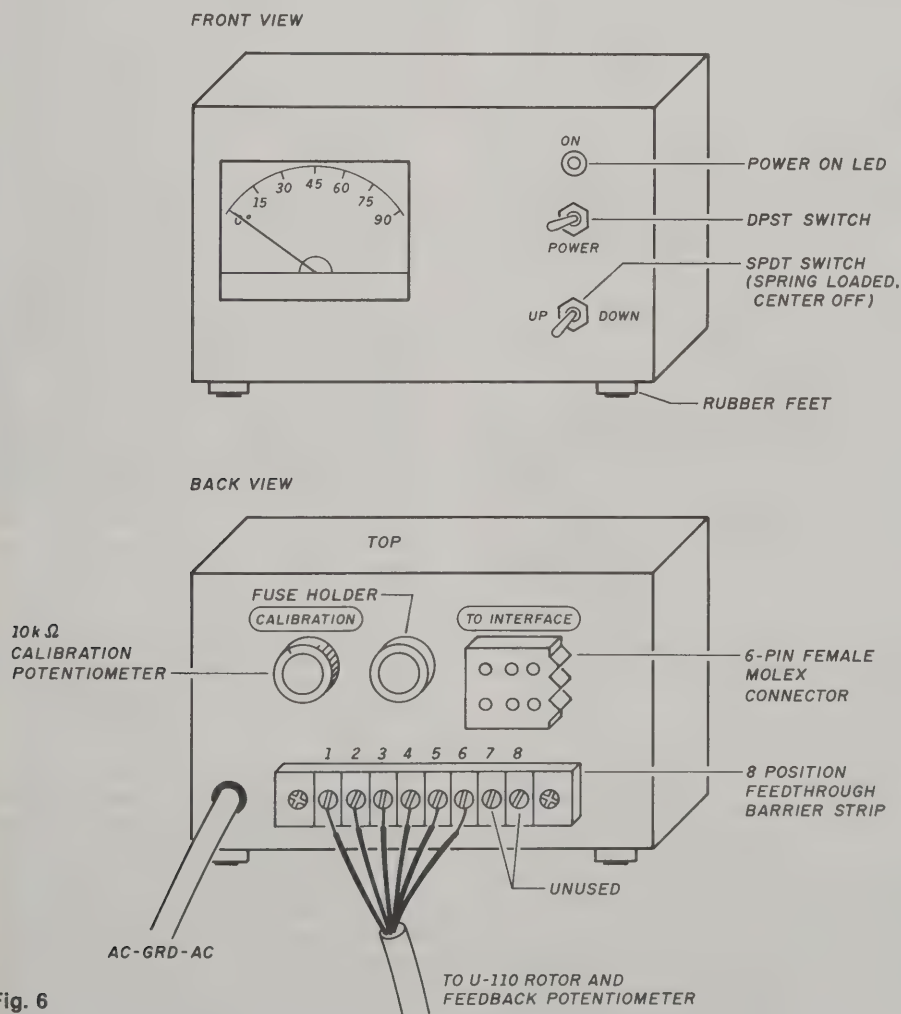


Fig. 6

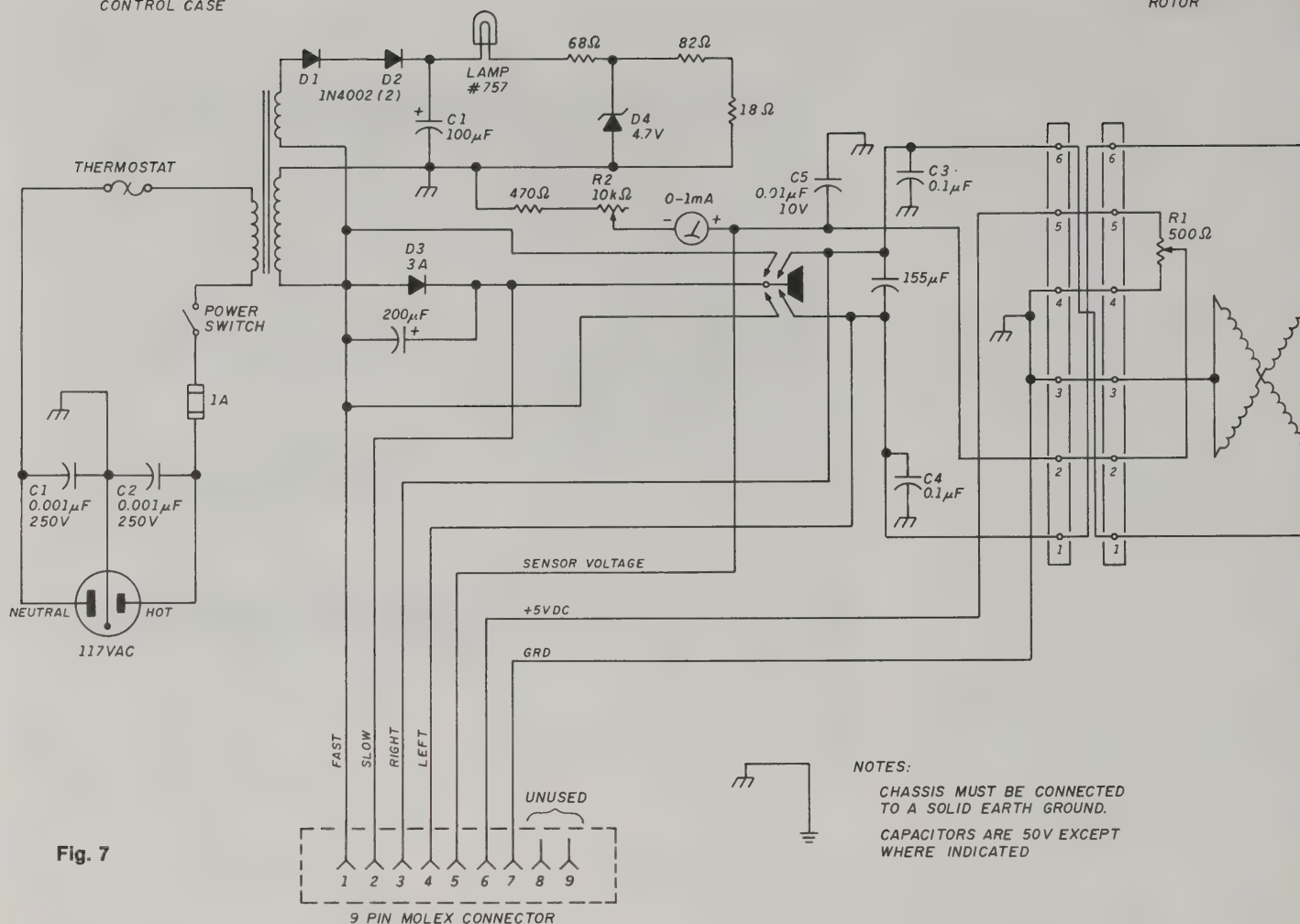


Fig. 7

mounted within the rotor housing, adjust the orientation of the potentiometer gear such that when the rotor is rotated (with the HD-73 controller) fully counter-clockwise (looking down from above the top of the motor housing), the AZ. RAW DATA reading should flicker between 0 and 1. Note: The rotor has a physical stop at both ends of its travel range. Be careful not to continue to hold the HD-73's rocker switch down after the motor reaches either end of its travel range. You may damage the motor if you continue to do so.

Rotate the HD-73 rotor clockwise (with the HD-73 controller). Notice that the AZ. RAW DATA values displayed on the C64 screen increase in value as the rotor is turned clockwise. If the opposite effect is observed, reverse the outer two wires leading to the replacement Spectrol potentiometer. Rotate the HD-73 FULLY CLOCKWISE. Measure the voltage at TP2 (see Fig. 3). Adjust the voltage at TP1 via the 50k-ohm trim potentiometer (R17) such that TP1's voltage is exactly $\frac{1}{2}$ TP2's voltage. The AZ. RAW DATA box displayed on the C64 screen should display either 254 or 255. The HD-73 feedback potentiometer and interface A/D converter are now calibrated. Tighten down the screws holding the HD-73 motor housing

together. Type "Q" on the C64 keyboard to exit the raw data display monitor. Type "B" to exit the CALIB TST program. Turn off the tracking interface.

Elevation Feedback Potentiometer Mounting and Calibration

Mounting Details:

Mount the precision servo potentiometer to the potentiometer-boom mounting bracket as shown in Fig. 9. Use either a surplus instrumentation single turn potentiometer or a Spectrol (132-0-0-501) potentiometer with a suitably weatherproof housing of your own design. Attach the mounting bracket to the boom using a $1\frac{1}{2}$ -inch U bolt or hose clamps. The square metal arm should attach to the shaft of the servo potentiometer using a set screw.

Calibration of Elevation Potentiometer:

Load and Run "CALIB TST", 8. Follow the instructions given by the program. Loosen the set screw on the square metal arm and remove the arm from the potentiometer. Rotate the potentiometer shaft while glancing at the ELE. RAW DATA box displayed on the C64 monitor. The ELE RAW data values should change as the servo potentiometer is rotated. If C64

screen shows characters instead of numbers are displayed in the ELE data box on the screen, the tracking interface is not turned on. Attach a strip of masking tape on the end of the horizontal Fiberglass boom. With a pen or pencil, draw a straight line across the masking tape from one edge of the boom to the other edge. With the elevation controller turned on, rotate the Fiberglass boom such that the line on the masking tape is parallel with the ground. This line will serve as our 0 degree elevation reference. While glancing at the ELE. RAW DATA box on the screen, rotate the potentiometer shaft so that the ele. raw data values flickers between 0 and 1. Re-attach the square metal arm to the potentiometer shaft being careful not to disturb the position of the shaft. Check the ELE RAW DATA box on the C64 screen to verify this. If the ELE RAW DATA value has not changed, tighten down the square metal arm set screw to the potentiometer shaft. Rotate the Fiberglass boom using the elevation controller such that the ELE. RAW DATA values increase in value. Stop the elevation rotor when the line on the masking tape (at the end of the boom) is perpendicular to the ground (i.e. 90 degrees elevation).

Carefully write down the ELE RAW

DATA value on a piece of paper for later reference. This value will be the 90 degree elevation constant. Typical values for this constant are in the range from 25 to 64 depending upon the value of the resistance and the precision of the chosen servo potentiometer. Press "Q" on the C64 keyboard to exit the raw data display monitor. Press "A" to select the elevation constant save option. Type in the 90 degree elevation calibration constant previously written down on a piece of paper and press return. The computer will ask "ARE YOU SURE ? (Y or N)" Type "Y" if the correct calibration constant has been correctly entered. The 90 degree calibration constant will now be written to a disk data file called CALCONST. This file will be called by MAPTRAKPLUS at a later time. Press "B" to exit the program.

Calibration of the HD-73 and U-110

Controller Meters:

HD-73 Calibration:

Turn on the HD-73 controller and 5V + power supply.

Calibrate the meter as described in the HD-73 owners manual supplied with the rotor unit.

U-110 Calibration:

Construct a template to be fitted inside the U-110 control meter as follows:

a. Cut out a white paper template to fit over the existing 0-1 mA meter template. Use a glue stick to temporarily attach the new template over the old one. Make sure the meter needle does not touch the template during any of its movement range.

b. Turn on the U-110 controller and 5V + DC power supply and rotate the horizontal elevation boom to 0 degrees elevation. Use the line on the masking tape at the end of the boom as a elevation reference. (The line on the masking tape should be parallel with respect to the plane of the ground, as seen from the end of the boom.) The input voltage to the elevation meter should read approximately 0 volts. Using a pen-

cil lightly mark a dot on the white template underneath the meter needle two-thirds along the needle length from the meter coil. Rotate the elevation boom to 90 degrees elevation. Mark another dot under meter needle in this new needle position. Carefully remove the template from the meter and using a protractor or compass, swing an arc between the two dots. Subdivide the arc into 18 equal segments and mark each segment in five-degree increments. Carefully fit the new template permanently over the old 0-1 mA template. Reassemble the transparent meter window to the meter housing.

Tracking System Testing

Load and Run "RTR CTL TST", 8. Follow the instructions given in the program. Press function keys F1 to F6 to verify that each function control key turns a rotor in the proper direction as indicated on the C64 screen. As a function key is pressed, the proper rotor status LED should light. For example if function key F1 is pressed, the HD-73 rotor should rotate counter-clockwise (looking down from above) and the green "SLOW LEFT" LED should light. If the rotors turn in the wrong direction or a LED does not light when a function key is pressed, recheck your wiring.

After the rotor controller meters are calibrated, rotate the HD-73 rotor such that the azimuth meter needle points exactly at North. Rotate the elevation rotor to read 0 degrees on the elevation meter. The calibration and testing of the tracking system is now complete. Turn off both rotor control units and mount the rotator assembly on a mast or tower outside with both antennas attached and statically balanced on the nonmetallic horizontal (Fiberglass) boom. The antennas should be mounted on the horizontal antenna boom such that they are pointing towards true North and are at 0 degrees elevation. If your QTH is in the northern hemisphere, use the North Star as an azimuth reference. Otherwise, be sure to account for magnetic

deviation when using a compass as a reference. Consult your local geological survey office for information on your local magnetic deviation.

Tracking System Operation

The tracking system is fairly simple to operate once the equipment is set up and calibrated. For best results, follow the instructions given below in order:

a. Read the MAPTRAKPLUS manual and addendum.

b. Turn on the C64 computer and set your site information into the "QUICKTRAK" data file as described on page one of your SUPERTRAKPLUS manual.

c. Load and Run MAPTRAKPLUS.

d. Turn on the C64 OSCAR TRACKING INTERFACE. Make sure the 5V + DC power supply is also turned on. The interfaces "power-on" LED should now be lit.

e. Turn on the HD-73 Azimuth Controller.

f. Turn on the U-110 Elevation Controller.

g. Enter the letter(s) corresponding to the satellite(s) you wish to track. If more than one satellite is selected, then MAPTRAKPLUS will ask which satellite is to be tracked with the antenna array.

The world map should be displayed on the C64 screen along with the satellite(s) (represented by a white sprite) overlaying the map. The white sprite represents the current satellite being tracked. The other satellites are represented by colored sprites. The TRKST (track status) column (located in the lower right hand corner of the screen) will print a "TRK" underneath the column heading when a satellite is "physically" being tracked by the antenna array. Only when a satellite has a elevation greater than 0 degrees above your horizon will it be tracked by the antenna array. MAPTRAKPLUS cycles through the process of calculating the position of a

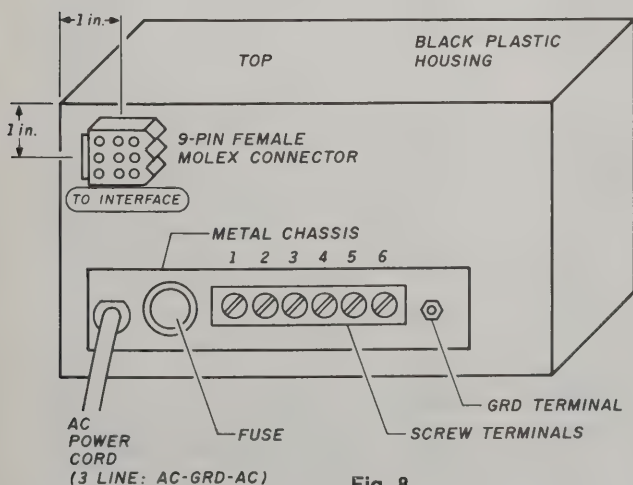


Fig. 8

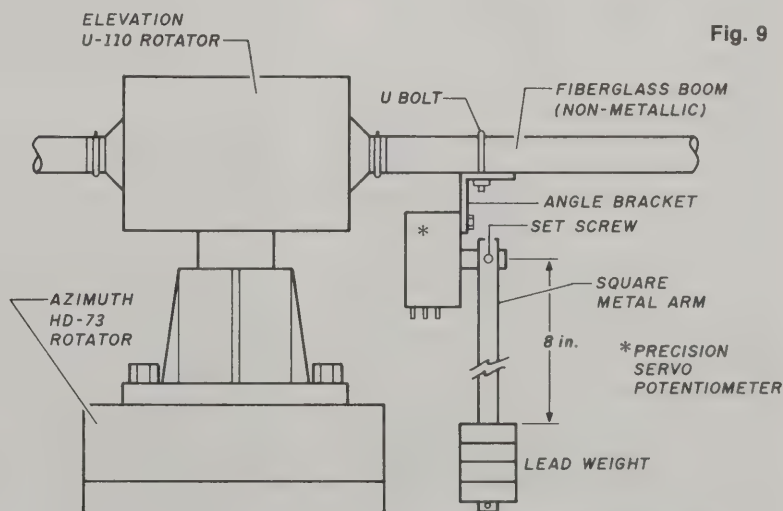
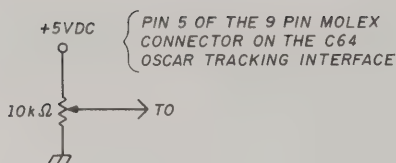


Fig. 9



NOTE:
THE VARIABLE VOLTAGE GENERATOR MAY BE USED TO TEST THE A/D CONVERTER. SEE TEXT FOR DETAILS ON THE TEST PROCEDURE.

Fig. 10

satellite, displaying the satellite sprite on the screen, and controlling the antenna rotors. Only when the interface is activated and consequently controlling the antenna motors will TRK be displayed on the screen.

Function key F1 aborts the tracking controller process for one tracking cycle and

simultaneously stops the antenna rotors. F7 returns you to the main menu. F1 and F3 advance and retard the clock by 10 seconds.

Conclusion

The C64 OSCAR TRACKING SYSTEM has been used successfully at my QTH for the past nine months and has simplified the operation of my shack tremendously. It is no longer necessary to manually update the position of the OSCAR antennas while juggling tracking, logging, and QSY-ing (due to Doppler shift), not to mention trying to carry on an intelligent QSO. Designed primarily for low orbit Phase-2 satellites (RS, FO, and UO series plus the upcoming MicroSat and EDSAT satellites) this tracking system is also useful for tracking higher orbit birds.

Acknowledgements

I would like to thank May Koehler for encouraging me to finish this project and John Obermeier, P.E. for reviewing this material.

References

1. *HD-73 Heavy-Duty Rotator Owner's Manual*, Alliance Manufacturing Co., Alliance, Ohio.
2. Automatic Control for the Alliance HD-73 Heavy-Duty Rotator, Joe Mehaffey K4IHP, *QST* January 1983, Volume LXVII, Number 1, pp. 17-19.
3. Adventures in Satellite DX-ing, Part 3, Dick Jansson, WD4FAB, *QST*, June 1986, pp. 29.

Parts List for the C-64 OSCAR Tracking System

C64 Oscar Tracking Interface

Integrated circuits:

U1 74LS373 Octal Latch
U2, U3 74LS04 Hex Inverter
U4 4066 Quad Bilateral Switch
U5 ADC084LNC 8 bit A/D Converter

Resistors:

R1-R3 10k ohm 1/4w
R4-R9 4.7k ohm 1/4w
R10-R16 330 ohm 1/4w
R17 50k ohm P.C. board Pot. (271-219)

Capacitors:

C1-C4 0.1uF 10V disk capacitors
C5 25uF 10V electrolytic cap.
C6 150pf disk cap.
C7-C8 0.01uF disk cap.
C9 100uF 10V electrolytic cap.
C10 0.001uF 10V disc cap.
C11 0.01 disk cap.

Diodes:

D1-D12 1N914 (1N4148) (276-1620)
D13-D14 1N4733 5.1V Zener Diode (276-565)

Transistors:

Q1-Q6 2N2222 NPN Gen. Purpose Transistor

Relays:

K1-K6 SPDT 125 VAC @ 2 Amp, 5V 72ma relay (275-243)

LEDs:

DS1-DS2 Green LED (276-022)
DS3-DS5 Red LED (276-041)
DS6-DS Yellow LED (276-021)

Misc.:

(1) 9pin female locking connector (Molex Socket) (274-239)
(1) 6pin female locking connector (Molex Socket) (274-236)
(1) Binding Post (Black) (274-661)

(1) Male 25 position D subminiature connector (276-1547)
(1) Female 25 position D subminiature connector (276-1548)

(1) Hood for male D subminiature connector (276-1549)
(1) 1/8" Two Conductor Mini Jack
(1) 1/8" Two Conductor Plug (274-286)

S1 Mini SPST Switch (275-634)
(1) 22pin connector for C64 User Port
(1) 5 foot 10 line computer ribbon cable
(1) Metal Cabinet 8"x6"x2"

HD-73 Controller and Rotor (Modification)

Capacitors:

C1-C2 0.001uF 250V Disk Capacitors
C3-C4 0.1uF 50V Disk Capacitors
C5 0.01uF 10V Disk Capacitors

Resistors:

R1 500 ohm single turn precision linear servo potentiometer (Spectrol Model 132-0-0-501)
R2 10k ohm linear potentiometer (271-1715)

Misc.:

(1) AC power cord (AC-GRD-AC) with plug
(1) 9pin female locking connector (Molex Socket) (274-239)

U-110 Controller

Capacitors:

C1-C2 0.001uF 250V Disk capacitors
C3 0.01uF 50V Disk caps.
C4 15uF 50VAC capacitor
C5-C10 0.1uF 50V disc caps.

Resistors:

R1 10k ohm linear potentiometer (271-1715)
R2 1k ohm single turn precision linear potentiometer
Surplus instrumentation model with weatherproof housing.
R3 330 ohm 1/4w resistor

Misc.:

(1) U-110 Rotator Motor Unit
(1) 117-30 VAC @ 1 amp Transformer
S1 DPDT Switch 125 @ 2 amp (275-614)
S2 SPDT switch 125 @ 2 amp Spring return center off
(1) 6' AC power cord (AC-GRD-AC) w/ plug
(1) Fuse holder w/ 1amp slow blow fuse
DS1 Red LED (276-041) w/mount
M1 0-1ma meter
(1) Metal Box 6"x5"x4"
(1) 8 position feedthrough barrier strip (274-653)
(1) 6pin female locking connector (Molex Socket) (274-236)
(2) Five-Lug Tie Points (274-688)

Cables:

(2) 6pin male locking connector (Molex Connector) (274-226)
(2) 9pin male locking connector (Molex Connector) (274-229)
(1) 6' 6 line cable #22 gauge w/ shielding
(1) 6' 9 line cable #22 gauge w/ shielding.

Parts Suppliers:

1) Radio Shack
2) Jameco Electronics
1355 Shoreway Road
Belmont, CA 94002

Dear Joe... (from page 3)

ing", but still, please accept these comments as constructive criticism.

— Hanspeter Nafzger, HB9AQZ

(Your local packet BBS has element sets updated weekly. If you do not have packet capability you probably know someone who does and could download them for you. In view of this wide dissemination of the element sets, should we include them in the Journal? — Joe.)

Dear Joe: I hope that you will include the Keplerian elements for all our birds in each issue of the *Journal*. I had requested that this be done in ASR a number of months ago and had received a response to the effect that it was passe. The solution offered at the time was for me to tune in to the AMSAT Net on Sundays. My attempts in this regard have been unsuccessful.

Besides, I am rarely available for this purpose on Sundays.

How about doing the unthinkable and providing the data as requested. Right now my Keplerian data are hopelessly out of date. The only way I can find AMSAT-OSCAR-13 is by trial and error. — Wm. L. Schreiber, NH6N

(As to your concern that your AMSAT-OSCAR-13 element set is hopelessly out of date, this should not be true unless it is well over a year old, which is clearly not possible in the case of AMSAT-OSCAR-13. You should be able to get fair predictions by either turning the "DRAG" element off in your tracking program or setting it to "0" in the data file. Drag should not be used after a week or so from the element set epoch time; it is a crude linear fit to very complex physical behavior and its usefulness degrades rapidly outside of the time period for which the element set is intended. — Courtney, N5BF)

More Suggestions

Dear Joe: What about having a buy, sell, swap column or section in the *Journal*? It would be mainly for Ham Gear and Satellite related items. — Bob Jones, WB7VMA

(Sounds like a good idea to me. I'll publish items from AMSAT members on a space-available basis for free. To start with, anyone interested in a matched pair of EIMAC 7289 triodes, won at the 1988 Annual Meeting, please contact G3ZCZ at (301) 593 6136. It wouldn't be right to build a flip-flop out of them. — Joe.)

Getting it Out

Dear Joe: The May issue is most interesting. I'm taking it along to the International Telecommunication Union (ITU) Plenipotentiary Conference that begins this

(Continued on page 22)

New UoSAT-OSCAR-11 Gateway Station On-line

By

Ross Forbes, WB6GFJ

Post Office Box 1

Los Altos, CA 94022

This project began during a visit with Graham Ratcliff (VK5AGR). He suggested that a simple way for us to exchange packet messages was through the UoSAT California Gateway station of NK6K. After I returned home, this path worked for a while, but suddenly stopped. Upon inquiry to Harold Price (NK6K), I learned he was becoming more involved with work commitments and activities surrounding MicroSat. Therefore, he was interested in backing out of Gateway activities.

At the same time, Ted Harris (N6IU) expressed interest in having the Palo Alto (CA) chapter of the American Red Cross become involved in amateur satellite communications. I sent a letter to the University of Surrey asking if it would be possible for "us" to establish a new UoSAT Gateway station in the San Francisco Bay Area. It wasn't long before I received a positive reply from Jeff Ward (GØ/K8KA) and Martin Sweeting (G3YJO).

Unfortunately, our efforts did not produce a working DCE operation as quickly as we had hoped. Some of our DCE team changed due to job opportunities, and I had personal matters that required immediate attention. However, in April (89) N6IU and I decided it was time to finish the job. It also helped that UoSAT, G3AAJ, G3RUH, ZL1AOX, DB2OS and VK5AGR kept pestering me to, "Get going right away as nobody was active from the States!" So, every effort was made to get the receive modem and transmit encoder completed.

Frank Wyatt (N6FW) and I set out to complete the UoSAT modem and make sure the satellite station at the Red Cross was fully operational. After careful consideration, it was clear some work was still required to bring that station up to our expectations. Therefore, we put our "backup plan" into operation. We would complete the UoSAT modem/encoder, and install it at my location (about 4 km from the Red Cross). My station was already successfully receiving UoSAT-9 and 11 using a G3RUH UoSAT modem, plus my station was fully operational on Modes A, B, and J. The equipment includes a Kenwood TS-700A with an internal ARR GaAsFET

preamp, ICOM IC-N475A, Landwehr mast mounted 435 MHz preamp, 9913 coax on 145 MHz and LDF-4 hardline on 435 MHz. Antennas consist of two KLM 18-element 435-MHz crossed Yagi's and two KLM 14-element 145-MHz crossed Yagi's. The tracking system consists of an old Ham-M azimuth rotor and a Kenpro KR-500 elevation rotor. The computer used for the DCE is an IBM XT Clone running at 4.5 MHz. A Kansas City Tracker is being added to provide automatic antenna tracking.

In late June (89) the DCE equipment was finally completed. At the same time Wes Morris (K7PYK) completed his DCE equipment. In addition to operating an hf/vhf packet BBS in Scottsdale (AZ), his interest is to use the DCE as part of an educational program to teach digital communications in Nicaragua. Since he was scheduled to leave for Managua and begin setting up at the University, Wes and I decided that he would have one week to access the DCE, and I would use the following week. This would keep each of us from trying to access the DCE at the same time, and avoid interference problems. Wes was successful in commanding UoSAT-11, so the following week, I began testing our system.

On the morning of July 7th, UoSAT-11 came over the horizon and within a few minutes, I was successful in commanding the beacon from 145.825 MHz over to 435.025 MHz. However, that was all! Nothing else happened despite trying different commands. Having spent most of the last four years on OSCAR-10 and 13, I had forgotten how quickly things happen on low orbiting satellites. Thankfully, I switched the beacon back over to 145.825 MHz just as I was about about to lose UoSAT-11. While partially successful, it was puzzling why I wasn't able to get UoSAT-11 to respond. Was it Doppler? Was it the wrong command? What was it?

I remembered Graham Ratcliff (VK5AGR) had published a report on his first DCE experiences in the *AMSAT-Australia Newsletter*. After carefully reading his report, I realized the need to verify the phase of my own signal. Ah ha! It was reversed! Next, I realized it was necessary to pay close attention to the polarization of my uplink. Last, and probably the worst mistake, was I sent the wrong command! Somehow I wrote down the wrong information! Instead of switching the 145-MHz beacon off, and the 435-MHz beacon on, I was leaving both the 145-MHz and 435-MHz beacons on! Oh well, at least the

150-foot dish at Stanford University was only 1 km away if required.

The earlier pass I attempted to command UoSAT-11 was a horizon pass, with only eight minutes of access time. The next pass was overhead with 15 minutes to work with. UoSAT-11 came over the horizon, and I quickly sent the *correct* command to turn off the 145.825-MHz beacon and turn on the 435.025-MHz beacon. Nothing! Sorry, forgot the transmit polarization again! Again, I tried the command. This time events happened so quickly (and smoothly) I couldn't believe it! The 145.825-MHz beacon was silent, check in to your local Packet BBS, I tried a couple of the commands, and downloaded two messages with reports about the DCE status.

It had been almost two years since I had seen the software in operation at Graham's station, and I had forgotten how smooth the DCE works. Once a Gateway station asks for a specific message, the DCE takes over. The operator only has to track the satellite, and adjust for correct antenna polarization. The DCE software does all the work. Very quickly the message appears on your screen, "Successful Transfer Completed." It worked smoothly, so I quickly sent a message announcing my successful access. The DCE and associated software again handled everything smoothly and I was given the message, "Successful Transfer Completed." Good heavens it was almost too easy to believe! There was still time left in the pass, but I had performed my duties and confirmed the equipment worked properly. Therefore, I command the DCE off, and put UoSAT-11 back on 145.825 MHz. If you would like to learn more about the software used by DCE stations, you can get more information from the ARRL Amateur Radio 5th Computer Networking Conference papers available directly from the ARRL. The software is described in the paper by Jeff Ward and Harold Price, "The UO-11 DCE Message Store-And-Forward System."

WB6GFJ is the newest Gateway station to come on line and will provide a regular link between the United States and the other UoSAT Gateway stations. Currently there are Gateway stations located in England (GB2UP), West Germany (DB2OS), New Zealand (ZL1AOX), Australia (VK5AGR), Antarctica (ZL5BA), Pakistan (AP2SUP) and South Africa (ZS6SAT). Previous DCE stations in the United States have become inactive, or involved in other satellite projects. However, the DCE station at WA9FMQ has announced it will be back "on line" by the end of summer. Also, Bill Maston (WB7QKK), working closely with Wes Morris (K7PYK), has expressed interest in participating as another DCE station.

The DCE Gateway now in operation by

WB6GFJ is part of a system being developed by N6IIU at the Palo Alto (CA) Area Chapter of the American Red Cross that will lead to a fully automated traffic link between the ground and the satellite. Now that commands and traffic have been successfully exchanged between the California Gateway and UoSAT-OSCAR-11, the first goal has been achieved; a regular active Gateway station in the United States. The final plan developed by N6IIU is to have a working package that will provide unattended tracking of the satellite, and the exchanging and forwarding of messages between the ground and UoSAT-11.

Anyone may now send traffic to stations in countries with a DCE Gateway Station through UoSAT-11's DCE. In order for traffic to be sent via the UoSAT-11 DCE you must know the callsign of the packet BBS of the station who will eventually receive your message. Once you know the callsign of your friend, and his/her home BBS, you may now send your traffic for distribution to the DCE. Users should realize that steps to transfer messages to and from the DCE are still performed manually. Also, there is a finite amount of memory on the satellite. Therefore, messages sent just to test the system (or other attempts to "ping" the system) are not appreciated. The system *does* indeed work so users should leave their efforts to "ping" a system to automatic networks.

If you want to send a message via the DCE, first send your message via packet to the Gateway station. It should be addressed to WB6GFJ at the N6IIU BBS. The format to send your message to WB6GFJ is:

SP WB6GFJ @ N6IIU

When your local packet BBS prompts you for a message subject, you should respond with "DCE MSG." Next your BBS will prompt you for the text of your message. Be certain the *very first line* of your message contains only the following information:

SP [call of a friend] @[his home BBS call] < [Your Call]

For example, if WB6XYZ wishes to send a message to his friend VK8XYZ who has a home BBS of VK1XYZ, the first line of the text would read as follows:

SP VK8XYZ @ VK1XYZ < WB6XYZ

The next line under the "address" should include a subject for your message. You then type the text of your message. After you type your signature (or the last line of your text), you should then put the following on the very last line of text:

/EX

The following is an example message with the proper format as it should arrive at the N6IIU BBS.

SP VK8XYZ @ VK1XYZ < WB6XYZ

Greetings Via UO-11

Hi! I am sending you this message via the UO-11 DCE.

Hope you and your family are healthy. Please advise the date and time of our next schedule. 73, Bob

(WB6XYZ@N6IIU)

/EX

At this point you tell your local BBS to send the message, and via the magic of packet radio it will arrive at N6IIU in Palo Alto (CA). WB6GFJ will check into N6IIU every few days and download all messages intended for the DCE. The subject "DCE MSG" is the flag used to gather the DCE traffic off of the N6IIU BBS.

When your message is transferred to WB6GFJ, all messages intended for a particular DCE Gateway are combined into a single file, and then compressed. A special message header is added and it waits until the next available pass of UoSAT-11. When the satellite comes in range of a DCE station, the satellite is commanded into the DCE mode, which means the general users will see a series of message headers being sent by the satellite. If there are messages intended for the DCE station now using the DCE, the operator will probably first download the message(s) and then delete the old message from UoSAT-11's files. Next the DCE station will upload the messages. When a message is placed onto the DCE, a user will notice new message headers being sent. The message will remain on UoSAT-11 until it is taken off by the appropriate DCE station and subsequently deleted.

Messages replying to you may be returned via terrestrial packet BBS stations or via the DCE. If a reply is sent to you via the California Gateway, it will be taken off by WB6GFJ and put into the proper format for terrestrial packet. Next, it will be placed onto the N6IIU BBS to be forwarded to you at your home BBS.

While there are a limited number of DCE stations on UoSAT-11, anyone may receive information being sent by the satellite. All data/messages are transmitted on the 145.825 or 435.025-MHz beacon frequencies. UoSAT-11 transmits data at 1200-baud ASCII, however the bits are inverted, so unless you modify your "normal" modem, it will be very difficult to copy data. However, G3RUH developed a UoSAT modem that is simple to construct and provides the necessary inversion. The G3RUH UoSAT modem takes audio direct from the output of your rig, and converts the signals to RS-232 or TTL data. A printed circuit board of the G3RUH UoSAT modem is available directly from AMSAT-UK. You may pay for the board with your MasterCard or VISA card. Send inquiries for the G3RUH UoSAT modem board to AMSAT-UK, 94 Herongate Road, Wanstead Park, London E12 5EQ, England.

You may purchase terminal software to decode the data from UoSAT-11. Software is available for both the C-64 and PC compatibles. UoSAT Software, written by VK5AKJ, for the C-64 is available from AMSAT- Australia or Project OSCAR. Software for PC compatibles, written by N5AHD and A. Brown, is available from AMSAT-NA. Both programs allow the user to receive signals from UoSAT-11, save the data to disk, and process the telemetry blocks. Both programs have been used by WB6GFJ and work well. In particular, stations participating in the CSDP program sponsored by AMSAT-NA will be able to complete their telemetry assignment with either software package. In addition to telemetry and messages, there are weekly bulletins of interest to all OSCAR users. The software packages will allow you to capture this information sent by UoSAT-11. By monitoring the 145.825-MHz beacon frequency, users will hear the following transmitted:

Whole Orbit Data (WOD)

UoSAT-11 Telemetry

Message Headers

Keplerian Elements

OSCAR Bulletins

Digitalker (digitized voice still in operation)

If you are interested in learning more about UoSAT-11, there are two publications of particular interest. The *UoSAT Spacecraft Data Booklet* is published by the University of Surrey, and can be obtained direct from them for a small financial contribution. The Journal of the Institution of Electronic and Radio Engineers published a *Supplement on UoSAT-2* that is available either from AMSAT-UK or from the University of Surrey for a financial contribution. Both booklets go into detail about the telemetry format, messages and Whole Orbit Data transmitted by UoSAT-11.

Stations who are getting ready for MicroSat scheduled for launch in November (1989) should realise the format for using the UoSAT-OSCAR-11 DCE may in fact be different from proposed formats for MicroSat. Therefore, be certain to use the correct format for UoSAT-OSCAR-11 as stated above.

Epilog: While preparing information about using the DCE for messages, I spoke to officials at the American Radio Relay League (ARRL) regarding problems United States stations might have with third party traffic. The good news is that effective September (1989) new regulations for United States Amateurs go into effect. Under the new rules, it is clearly spelled out that communications between (among) Amateurs is permitted. Therefore, the ambiguity that existed in the past has been removed, and will allow United States Amateurs to exchange messages with other amateurs.

Sailing to the Moon

By

John M. Garvey, N6VHP

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A sailing expedition to the Moon is being considered as a way of commemorating both the International Space Year (ISY) and the 500th Anniversary of Columbus's discovery of the new world, both of which will take place in 1992. The Quincentenary Jubilee Commission¹, a non-profit organization established by the federal government to sponsor events in honor of Columbus's historic voyage, is working with the American Institute of Aeronautics and Astronautics (AIAA) to make this event (tentatively entitled "The Columbus 500 Space Sail Competition") happen.

The idea of a solar sail race to the moon is not in itself something new. A French organization, the Union for the Promotion of Photonic Propulsion (U3P) has been advocating this concept since 1981. The unique aspect of the current competition proposal is its connection to both the ISY and the Columbus Anniversary.

The current concept for the event will involve at least three non-government entrants, one each from Europe, Asia and the Americas (the continents Columbus left from, was going to, and actually arrived at). It will draw upon the experience developed from a number of similar events that have taken place in recent times, including the Pentax solar-powered car race across Australia, the America's Cup, the Statue of Liberty renovation and the 1976 American Bicentennial. A Request for Proposal (RFP) for preliminary design studies which would eventually evolve into the selection of actual design and manufacturing teams was issued in January 1989² and proposals are due by November 1989. As of June 20, 1989, some thirty teams had indicated interest in submitting a proposal, including fifteen from the United States, ten from Europe and five from Asia³.

It is anticipated that the ideal launch opportunity is for the fleet of solar space sailcraft to start off in low Earth orbit (at least 1000 miles) and then spiral out to the Moon, each with the ultimate goal of being the first to enter lunar orbit and/or pass within a yet-to-be-determined distance of the lunar surface. An alternative launch scenario is for each space sailcraft to ride into orbit as a secondary payload on another mission. This scenario would give each vessel tighter volume and mass constraints than a dedicated launch as well as

different starting orbits. This would require "handicaps" to be issued to each of the contestants so that arranging a fair start will be a difficult task. There are still many details that need to be resolved during the next year, particularly those associated with the launch vehicle(s) and initial orbit parameters. The AIAA has established a technical committee to address these issues. This committee will also oversee the evaluation of the preliminary design study proposals.

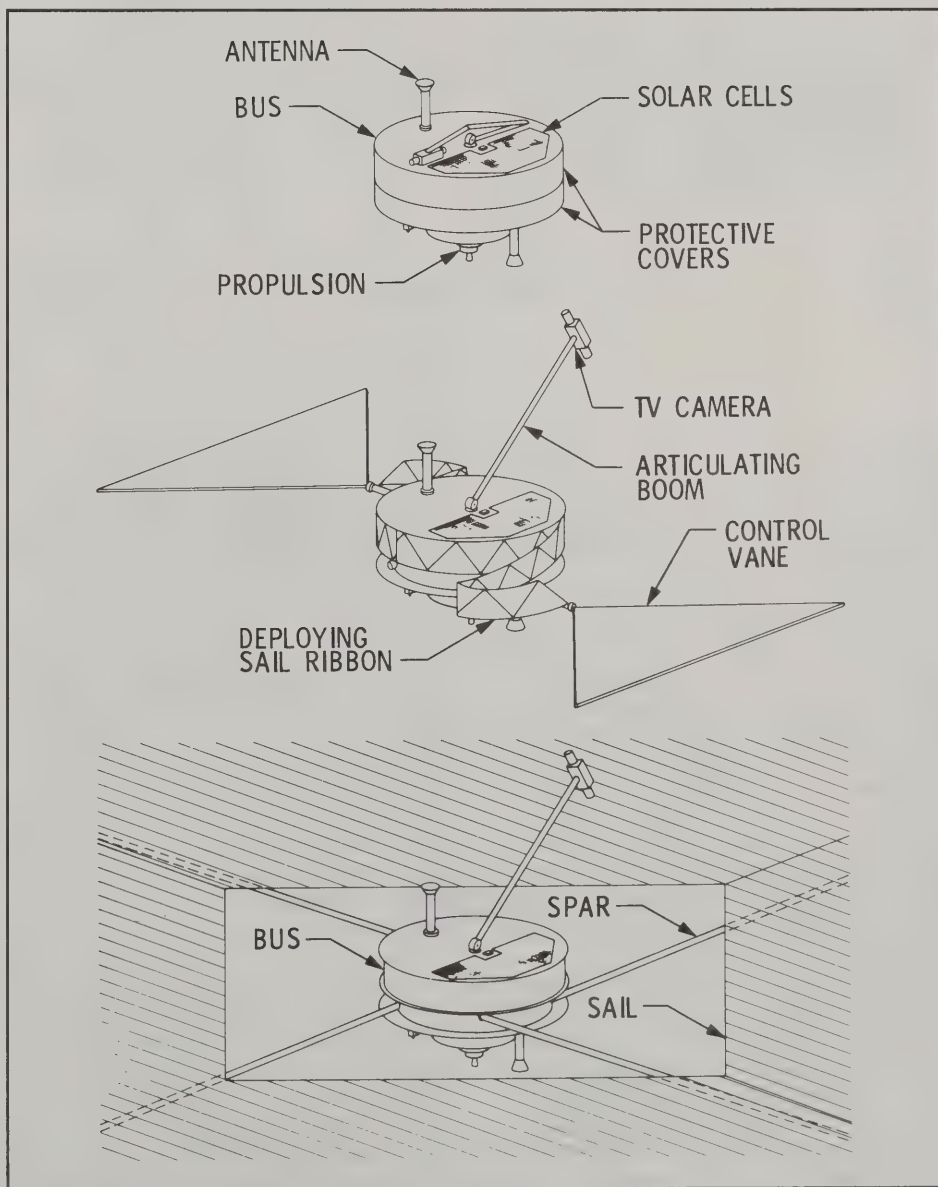
Solar Sailing Fundamentals

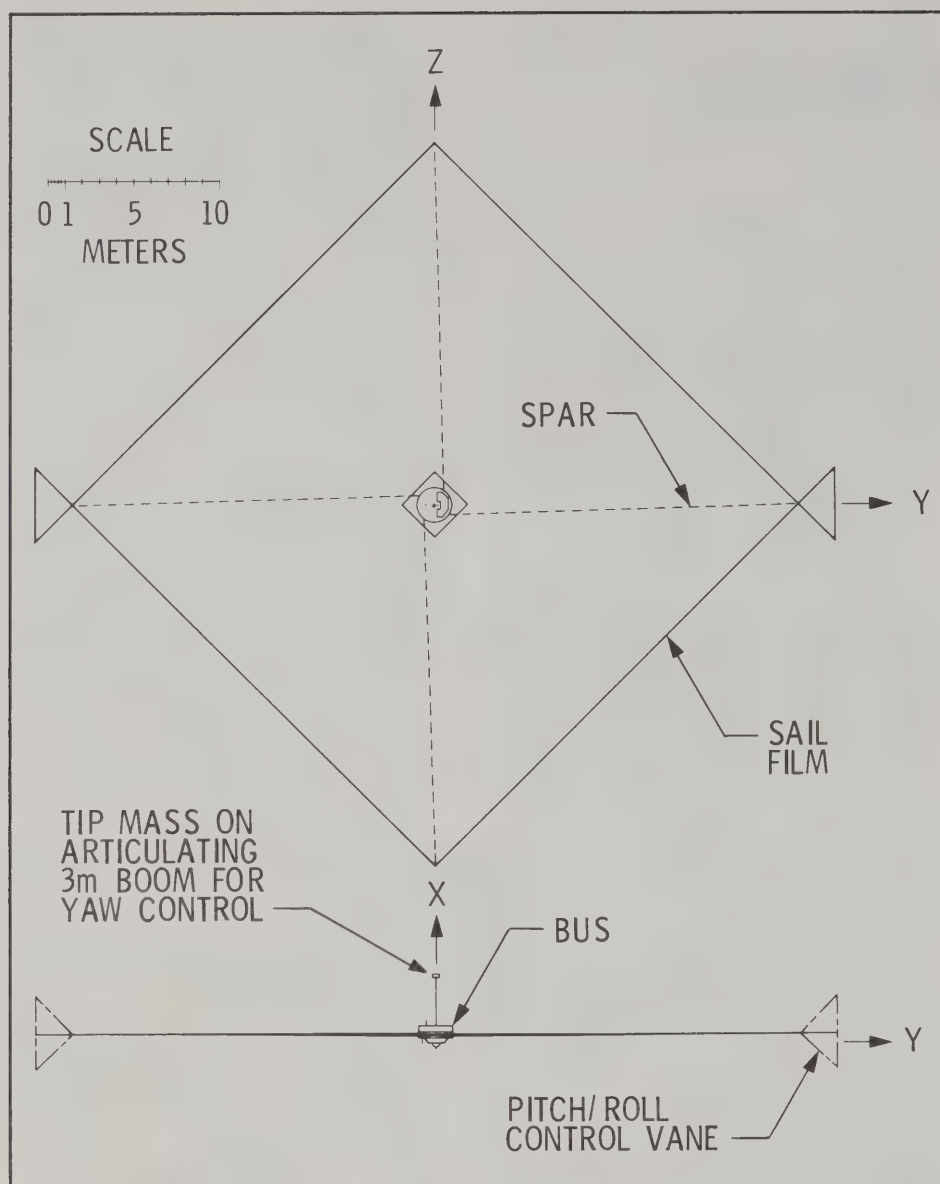
A solar sail is a large lightweight mirror that reflects light from the Sun to generate a thrust. In terms of physics, the momentum of the photons is transferred to the

space sailcraft. It is the actual light radiation and not the Solar Wind which imparts momentum to the sail and its payload.

Light pressure is generated by photons and has a value of 9 N/km^2 at the radius of the Earth's orbit around the Sun (one Astronomical Unit). The Solar Wind on the other hand consists of various charged particles and the force associated with it is several orders of magnitude lower than that generated by sunlight. The force of the Solar Wind is thus ignored in orbital trajectory calculations.

Solar Light Pressure has already been utilized in a positive manner. It provided temperature control for the AMSAT-OSCAR-6, 7 and 8 spacecraft by spinning the spacecraft so that the Sun did not beat down on a single surface for any long period of time. It was also used as a supplementary attitude control system on the Mariner-10 mission to Mercury. There, torques generated on a set of vanes helped reduce the consumption rate of propellants by the reaction control system. For most





other spacecraft, solar light pressure is a perturbation effect that is accounted for when performing station keeping and attitude control maneuvers.

The force due to solar light pressure is very small compared to that produced by conventional chemical rockets. This thrust however is continuous. Consequently given a sufficient amount of time and a high performance reflecting surface, a space sailcraft can undertake high energy missions that are not practical with existing propulsion systems which require consumable fuels. These missions include rendezvous trajectories to Halley's Comet, a Mercury Orbiter and possibly cargo deliveries to Mars in support of manned exploration of that planet^{4 5 6 7}.

In Russia as early as the 1920's Konstantin Tsiolkovsky and then Fridrikh Tsander had independently visualized the potential of Solar Sails. It was not until fifty years later when NASA's Jet Propulsion Laboratory (JPL) considered solar sail propulsion for the Halley's Comet Rendezvous Mission that the concept received

serious engineering attention. Unfortunately, because of a number of program constraints, electric propulsion beat the sail option for the mission and the issue became moot shortly after when Congress cancelled the mission in 1979. As a consequence, sail technology is in a Catch-22 situation. NASA program managers will not favor sail technology for their missions because it lacks flight experience as a primary propulsion system, and there are no government plans to test the technology in a demonstration flight. There has, however, within the last year been a renewal of low-level interest by NASA in solar sails. The Office of Exploration, which is responsible for assessing human exploration of the Moon and Mars, has recently directed the Lewis Research Center and JPL to review the potential for using large sails as an alternative propulsion system for delivering cargo to Mars. This interest is spurred by the significant reduction in mass-to-orbit that sails might offer. Conceivably, if the study results are positive, additional funding could become

available to address specific technology issues.

To get around this obstacle, a team of aerospace engineers in southern California (including some of the JPL sail study veterans) have been working to undertake a demonstration flight since the days of the original study. Under the banner of the World Space Foundation (WSF), a non-profit space research organization, they developed a sail fabrication device and actually manufactured several prototype sails during the early and mid-1980's. At that time when the objective was a single Engineering Development Mission, AMSAT-NA agreed to participate by supplying a substantial share of the avionics and ground support⁸. As space program veterans can attest, the biggest challenge for amateur space operations is obtaining the launch opportunity, and the WSF has not been successful in this area. This is partially due to the requirement that all solar sailcraft must fly at least 1000 miles above the surface of the Earth to avoid atmospheric drag, the unique requirements for payload deployment and other external events beyond their control. In fact, the WSF was in the final stages of negotiating a Joint Endeavor Agreement with NASA for a launch on the Shuttle when the Challenger accident occurred, thereby negating all such plans.

The ongoing association between AMSAT-NA and the WSF serves as the basis for Radio Amateur participation in the proposed sail expedition to the Moon. AMSAT's Board of Directors reaffirmed this relationship last June and as a result, Radio Amateurs are now actively supporting the preparation of the preliminary design proposal that is due this November. A number of other organizations are also part of the WSF team, including a major aerospace company (McDonnell Douglas), and a university (Utah State). Assuming that our team is eventually selected to build the American space sailcraft, AMSAT-NA will undertake the responsibility for the on-board command, telemetry and power subsystems, and will help establish the ground operations (telemetry, tracking and control) needed to support the flight. There have also been preliminary discussions concerning extra payloads that could be flown that would expand the involvement of both hams and scientists (i.e. communications transponders and a camera similar to the one to be flown on the WEBERSAT MicroSat which would provide data on the condition of the sail). Also under consideration are educational opportunities similar to those based on the UoSAT-OSCAR-11 Skitrek experience. There the Digitaler provided daily status reports on the progress of a joint Soviet-Canadian team as it journeyed across the Arctic polar ice. Students at many schools around the

world were able to monitor the satellite, track the progress of the expedition and learn a great deal about both the Arctic and the spacecraft in the process. A similar system could be utilized to report the progress of the competing sailcraft.

In view of the international aspects of this lunar expedition, there are several other mechanisms by which Amateur Radio operators could become involved. First, other Radio Amateur organizations may wish to support competing teams (as an example AMSAT-DL or AMSAT-UK and the University of Surrey may wish to provide services to a European team). Second, it may be desirable to build upon the existing AMSAT-OSCAR global tracking network to develop a united ground network which would support all race participants. This is particularly important because the sailcraft will be constantly changing attitude and will require continuous monitoring early on in their flight to develop an understanding of their behavior. The upcoming MicroSat fleet could be a major factor in creating such a flexible ground network.

Conclusion

If the Solar Sail Cup race is successfully implemented, it will demonstrate the utility

of an untried space propulsion system, thereby opening up new opportunities for space exploration. It would provide a new challenge for Amateur Radio. It would capture the imagination of the public (the sails should be visible from the ground). It would foster friendly competition between space enthusiasts around the world. The primary near-term challenges are the setting up of the program organization, lining up acceptable launch position(s) and, as always, raising adequate financing. Specific Amateur Radio issues include avionic subsystem design, frequency allocations, personnel support (the MicroSat and Phase-4 projects will soak up a lot of AMSAT's talents) and the nature of international amateur space activities. In the past AMSAT has met and overcome these issues, and, with luck, hard work and co-ordination and the spirit of cooperation that characterizes Amateur Radio, AMSAT will do the same again, thereby guaranteeing that 1992 will be a year to remember.

Acknowledgements

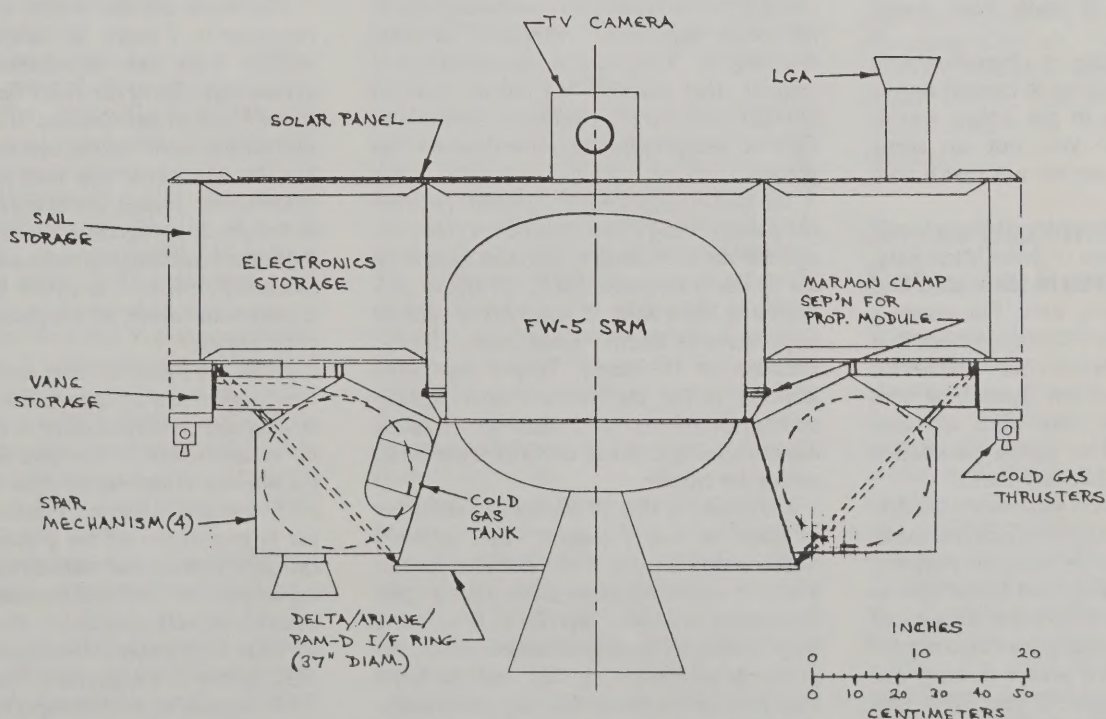
I would like to express my appreciation to AMSAT's Executive Vice President, John Champa, K8OCL, AMSAT's Vice President of Operations, Courtney Dun-

can, N5BF, and to Robert Staehle, President, WSF, for their guidance in the preparation of this article.

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WSF SOLAR SAIL VEHICLE, LAUNCH



- H. PRICE 3-6-89

Dear Joe... (from page 16)

month in Nice, France. There are sure to be lots of amateurs present as delegates. Speaking of the ITU, our British cousins (!) insist that it remain the International Telecommunication Union — no “s”! So the glossary on page 4 should be corrected. — Dex Anderson, W4KM

Sounding Off

Dear Joe: Why is AMSAT not doing anything for the General Membership?

This is an open letter to the AMSAT Board and to the membership in general. I intend in this letter to state my personal dissatisfaction with the way things are being done. All of the experimentation that is being done is well and good but it's time that a satellite was put in orbit that us little guys, with not much money and without vast yards for antenna arrays can get some use out of. I get more use from the RS MODE-A satellites than anything my own organization has put up in years. I can work through AMSAT-OSCAR-10 with small antennas, including verticals with barefoot rigs but cannot get a downlink from AMSAT-OSCAR-13 with the same gear. I have been told by others in AMSAT that this is because AMSAT-OSCAR-10 is “broke”. If this is the case, please break AMSAT-OSCAR-13 so that more of us little guys can work through it without having to buy a lot of expensive equipment (like big power supplies, power amplifiers, etc.) and if the situation is this bad for us then it surely is much worse for amateur operators in most third world countries.

Now you are putting up a bunch of birds that in general are going to benefit only a handful of stations in the entire world. Isn't it about time you put up some satellites *every one can use* not just a well heeled elite.

Just what is wrong with putting a Mode A transponder on one of these MicroSats. Or even (heaven forbid) be innovative and do something entirely new, like create a new mode workable with equipment that is readily available worldwide, like for instance a polar orbiter low flying bird with a transponder that has both up and downlinks in the two space passbands located within the 2-Meter band.

It's time to clean up your act AMSAT. We need and want SATS that can be worked from mobile and/or portable stations. We have the technology and know how so I for one feel its time to do something about it. Remember it's us little guys that are paying the bills and we aren't getting our monies worth it seems. If you think that I am the only one who feels this way you are very much mistaken. You will know when membership renewals start falling off and donations quit coming in. You

have been asking for reader feedback from members for the Journal, here's some, let's see it in print. — John H. McReynolds, N7JBO, AMSAT No. 20557

(Here it is in print. Let's see who agrees with you and who does not. You have raised some important issues, so I circulated your letter among the Directors and Officers for comment.)

My answer is basically as follows. AMSAT's spacecraft designers and builders are, in the main, volunteers. If we had to pay people to do what our volunteers do, the cost of AMSAT-OSCAR spacecraft would be so high that there probably wouldn't be any. When they decide what to build, they do look around and see what is out there, and what other sister organizations are doing. AMSAT-OSCAR-8 was built because the ARRL used it as a “quid pro quo” for providing funds for the Phase-3 Program. OSCAR-3 carried an in-band 2-Meter transponder simply because the builders wanted to see if they could build one using the state of the art of the time. And given that state of the art, every user had to aim blind at the spacecraft because they could not hear their signal coming back themselves. Regarding a Mode-A MicoSat, we have the technology, we don't have the project manager. — (Joe)

And further. . .

Yours is a question that we hear fairly often at AMSAT which deserves to be addressed in answer to the better question, “What is AMSAT doing for the General Membership?”

First there is the issue of Mode-A satellites. It has been AMSAT policy since AMSAT-OSCAR-8 that since someone in the world (namely Soviet Amateurs) was responding to the need for supposedly “entry level” satellites touching on hf which is supposedly more popular, that AMSAT-NA did not need to duplicate this effort. Furthermore, it would be difficult, and perhaps unwise to do so for two reasons.

The first is spectrum management. Another complaint AMSAT hears quite often from outside the ranks of satellite operators is that we use up lots of spectrum (like 29.3 MHz to 29.5 MHz and 145.8 MHz to 146.0 MHz) without any concern for its other possible uses, like FM channels on 10 Meters. To put even more satellites in the sky that use (and possibly overlap) the 10-Meter or 2-Meter satellite bands already used by existing satellites is obviously asking for trouble.

The second is that 10 Meters and the other hf bands do indeed support other activities besides satellite work. Since satellites provide a service within Amateur Radio that is complementary to hf (and superior to hf in many ways) it does not make good sense to do so competitively on frequencies that could be better used for other purposes, like skip communications. This is particularly true at this time because of the remarkable and still increasing sunspot cycle.

The AMSAT organizations of the world are

a community, each doing what they can to support the overall goal of sustaining Amateur Radio communications in space. Their contributions should compliment each other, not compete.

My experience with AMSAT-OSCAR-10 and 13 is that they are both a challenge to use. Since AMSAT-OSCAR-10 is no longer controllable, its antennas cannot be made to point at the Earth during most of its orbit. There are times near perigee, however, when AMSAT-OSCAR-10 is close to the Earth and the antennas are more favorable than they would be if the satellite were still under active control. It is very easy to work at those times. The penalty paid for this hour or two of good coverage per orbit is that it is very difficult to work nearly all of the rest of the time.

AMSAT-OSCAR-13 is aimed and scheduled so as to present a more consistent signal throughout its orbit. Currently, it is workable from apogee through perigee. After the mid-August re-orientation, distance and antenna pointing will favor the end of the orbit, after MA 160 (for the northern hemisphere). If you try to work it then you may have better results with minimal antennas. Note that if the satellite is at a high elevation from your location, vertical antennas will not do well.

The equipment really required to use AMSAT-OSCAR-10 and 13 is not expensive amplifiers and expensive power supplies but the best preamplifier and antenna system possible. The best preamplifier available on 2 Meters that I know of is less expensive than either a big amplifier or a big power supply. The May 1989 issue of 73, and other amateur literature, contain many articles describing very inexpensive but effective satellite antenna projects.

The general idea that satellite work is terribly expensive is, I think, ill founded. Certainly satellite work can be expensive. So can automobiles. Every car buyer has a choice between Hundayi and Cadillac. It is also untrue that satellite work requires vast arrays of antennas. In this regard you may be thinking of moonbounce. Indeed, one of my early interests in the satellite program is that operation does not require vast arrays of antennas. A 10-Meter antenna for Mode A is a little bulky, but for 2 Meters and above, an adequate array can be quite modest.

Given the choice between setting up a station to effectively work anywhere in the world on a regular basis via satellite or via 20 Meters, the job can be done for less space and less money via satellite. Antennas for Modes B, J, and L are comparable in size to TV antennas and need not be any higher off the ground than is required for turning and visibility clearance. With a good preamp, 25 Watts transmitter power is usually adequate, and would always be except for other high power stations causing satellite AGC to rise to unacceptable levels.

For dependable, controlling (i.e. comparable) performance on 20 Meters, I would expect to use a large antenna of at least three elements and preferably more, at least 40 to 60 feet (i.e. tower rather than tripod), the higher the bet-

ter. I would expect to use a kW amplifier (with power supply) and a rig capable of driving it properly. At flea market prices, this might all be done for \$1500-\$2000. I have worked an amateur on Mode B who claims that he set up his entire station (at flea market prices) for about \$700.

The MicroSats about to be launched will have a larger direct and indirect user base than many suspect. DOVE will be usable to anyone with a two Meter FM receiver. This includes nearly every amateur in the world and literally thousands of others with scanners and other inexpensive high band receivers. The two packet bulletin board satellites are a response (in part) to a need that is now several years old for more efficient packet traffic handling. Packet mail response and non-real time amateur communications are expected to improve dramatically with the PACSATs. If you can work Mode J now, you are only about \$250 away from being able to use the satellites directly (\$110 if you already have a TNC) and if you use packet bulletin boards to send mail around the countries, you are an indirect user already.

It is my observation that the MicroSats may not appeal to the majority of the current AMSAT-NA membership but that they appeal greatly to a new group of Amateurs who have not been very interested in satellites before. This is great news in that it can result in significant growth and diversification within AMSAT-NA, something we can certainly use.

The idea of a satellite with uplink and downlink both on 2 Meters was tried on OSCAR-3. Since then, it has been judged a more effective use of weight and space on the satellites not to use the cavities and other equipment necessary to duplex on the same band. In any case, such a satellite would not be approved for other reasons.

I live in the Los Angeles basin where 2 Meters is extremely crowded. This is not a unique situation. After AMSAT-OSCAR-13 was launched, we faced considerable difficulties with the local 2 Meter coordinating bodies over use of the 144.3 MHz to 144.5 MHz band. Legally, satellites can use 144-146 MHz, it is only by gentlemen's agreement that 145.8-146.0 MHz and 144.3-144.5 MHz are earmarked for satellite work and it cannot be shown in any bandplan except the ARRL's recommended plan that 144.3-144.5 MHz exists as a satellite band at all (and this only covers Region 2). Neither satellite users nor other users of the 2 Meter band have been very gentlemanly about this.

And, these problems will only get worse if we put up more Mode A satellites (or Mode B or Mode J for that matter).

To demonstrate how difficult it would be to put up a 2 Meter repeater on a satellite, get a coordination for a 2 Meter pair in a major United States city (which in itself is probably not possible, although the satellite would use, as you suggest, the satellite bands and would therefore only have to coordinate frequencies with other satellites). Then put the repeater on the air and see what quantity and quality of utilization it gets. Now multiply the quantity

by 50 (increasing the number of potential users in view at any given time) and you will soon conclude that such a satellite would be useless, (at least when over the United States, Japan, Europe, and other regions heavily populated by Amateurs) particularly in an emergency when utilization would likely increase three or four fold.

On the one hand, the satellite would be useless for the very reason that the required ground equipment is readily available to virtually everyone. On the other hand, AMSAT-NA would certainly receive complaints that it did not use a standard 600 kHz split!

Portable and mobile satellite operations are fairly common in any case. Documented mobile satellite operations appear in AMSAT publications dating back into the 70s. This year at Field Day there were several hundred portable operations using AMSAT-OSCAR-13. If AMSAT-OSCAR-13 were not a multiple use linear transponder on which FM and the "simpler" modes were discouraged, this level of activity could not have been supportable.

More along these lines, satellites should be usable from mobile rigs, and we do indeed have the technology to put up satellites that have greater power output and that could be used with less sophisticated receivers and antennas. The technology is very expensive. Roughly half the cost of modern amateur satellites is their solar cells. Given the electrical power, the rest would be relatively straightforward. This is a major goal and item of concern in discussions regarding future projects like Phase-IV or Phase-III D. Since most of AMSAT's talent has historically been and still is in the area of engineering and technology and not in money raising, the satellites have emphasized technology and have been weak signal operations. We need talent in the money raising area to bring about what you suggest. Any ideas on where to get such volunteers?

In response to pressures from within Amateur Radio to alleviate congestion on crowded bands and populate new ones and pressures from outside that are hostile to Amateur Radio, AMSAT has taken the lead in advancing technologies to more efficiently use the spectrum now available. The fact that it is harder to get set up personally to use these resources is an area in which AMSAT could also use some help. Construction and operating practice articles are welcome in any of our publications as is any recruiting that can increase our market share so that equipment manufacturers will be more inclined to support our needs.

AMSAT's main failure with the membership has been in not communicating information like this more thoroughly in the context of Board elections and in the publications. It is for this reason that I have taken time away from other seemingly more pressing responsibilities to answer your points as completely as possible.

In summary, the decisions about what sort of satellite development and support projects should be undertaken are not made lightly. Many issues must be considered including spectrum management, frequency utilization,

political stance, other resources available, launcher constraints, the future of Amateur Radio and the amateur satellite service, and so on. Admittedly, the price and availability of appliance grade or other ground equipment has often taken a back seat to considerations like amateur band preservation in these decisions, but I think it is unfair to say that AMSAT is "not doing anything for the General Membership" in this respect. AMSAT is attempting to advance the state of the art, occupy and utilize frequencies in the amateur service, and generally promote and preserve Amateur Radio. And, we need help. — Courtney Duncan, N5BF, AMSAT V.P., Operations.

AMSAT's Satellite Frequency Card

A limited number of heavy-duty plastic-laminated two-color two-sided AMSAT Frequency Cards are still available from AMSAT Hq. In chart form, this 9 x 14-1/4 inch reference guide, prepared originally by WA2LQQ, lists all active Amateur Radio Satellites and their important Uplink/Downlink and beacon frequencies along with modes of operation and other details of general interest. While they last, a \$5.00 donation (U.S.A. and Canada) plus \$1.00 to cover postage and packing will get you one of these by return mail. For overseas, a \$10 donation (U.S. dollars) includes shipping. More than 1000 are in use today, but there are just a few left on a first-come basis. Good for a gift to an up-and-coming youngster interested in satellites or an active amateur not presently operating OSCAR. Send donations to AMSAT Headquarters, 850 Sligo Ave., Silver Spring, MD 20910 or call Hq. at 301-589-6062 with your VISA/MC card number.

Some Upcoming Dates to Remember...

On or about November 10, 1989, from the spaceport of the European Space Agency, in Kourou, French Guiana, South America, it is expected that an Ariane IV rocket will carry six Amateur Radio satellites (MicroSats) into orbit. Each satellite measures nine inches on a side and will carry different communications systems. See *The AMSAT Journal*, Volume 12, Number 1, dated May 1989, page 3 for an indepth discussion of the satellites and the MicroSat program.

Also, the 1989 AMSAT Space Symposium and Annual Meeting are to be held in Des Moines, Iowa November 3 through November 6, and will be hosted by the Central Iowa Technical society. See *Amateur Satellite Report* No. 190 for details.

AMSAT Orbital Elements from W0RRPK

Active OSCAR Satellite Transponder/Beacon Frequencies

Satellite:	UO-9	AO-10	UO-11	AO-13
Catalog number:	12888	14129	14781	19216
Epoch time (89):	217.09131522	213.28003163	214.66482505	210.94724247
Element set:	664	420	486	40
Inclination:	97.5477	26.0666	98.0019	57.1340
RA of node:	274.2439	252.0612	272.1141	197.4940
Eccentricity:	0.0002315	0.6052492	0.0012735	0.6764936
Arg of perigee:	167.0651	63.7206	168.8636	208.5144
Mean anomaly:	193.1007	345.3327	191.2830	86.4115
Mean motion:	15.70332599	2.05879250	14.63801920	2.09699836
Decay rate:	1.00857e-03	6.7e-07	1.237e-05	2e-08
Epoch rev:	43664	4614	28934	863

Satellite:	MIR	MET-2/16	MET-2/17	MET-2/18
Catalog number:	16609	18312	18820	19851
Epoch time (89):	219.63743832	213.03461860	213.06388990	213.09677149
Element set:	977	298	137	60
Inclination:	51.6200	82.5557	82.5425	82.5240
RA of node:	106.0067	184.0009	244.8891	123.4752
Eccentricity:	0.0009439	0.0014287	0.0017407	0.0013869
Arg of perigee:	245.9808	71.8969	139.0929	176.5275
Mean anomaly:	114.0408	288.3732	221.1530	183.5987
Mean motion:	15.58075857	13.83495188	13.84187007	13.83823526
Decay rate:	2.8540e-04	2.18e-06	1.27e-06	1.17e-06
Epoch rev:	19918	9871	7589	2129

Satellite:	MET-3/2	NOAA-9	NOAA-10	NOAA-11
Catalog number:	19336	15427	16969	19531
Epoch time (89):	217.73110957	215.32533395	218.07359174	218.33460650
Element set:	232	410	259	112
Inclination:	82.5415	99.1471	98.6373	98.9425
RA of node:	140.6208	203.2007	247.6148	162.1197
Eccentricity:	0.0018999	0.0015120	0.0014507	0.0013231
Arg of perigee:	22.9365	177.4185	103.1080	89.0380
Mean anomaly:	337.2485	182.7068	257.1719	271.2303
Mean motion:	13.16858041	14.12101460	14.23108208	14.11087394
Decay rate:	3.91e-06	3.17e-06	4.68e-06	3.76e-06
Epoch rev:	4943	23910	15103	4454

Satellite:	RS-10/11	FO-12	AJISAI	SALYUT-7
Catalog number:	18129	16909	16908	13138
Epoch time (89):	219.00725632	197.10014353	202.18032835	219.61534693
Element set:	839	163	147	693
Inclination:	82.9252	50.0167	50.0064	51.6092
RA of node:	200.6118	209.4498	193.5888	65.2420
Eccentricity:	0.0010326	0.0011078	0.0011257	0.0000790
Arg of perigee:	272.3283	60.4152	74.2487	172.7201
Mean anomaly:	87.6689	299.7766	285.9588	187.4098
Mean motion:	13.71993434	12.44400597	12.44379520	15.43614519
Decay rate:	6.7e-07	-2.5e-07	-3.8e-07	1.4769e-04
Epoch rev:	10636	13300	13364	41613

NOTE: All frequencies are in MHz.

All communications within the transponders conform to the Satellite User's Bandplan first proposed by Pat Gowen G3IOR and Joe Kasser G3ZCZ in the September 1977 (Volume IX Number 3) issue of the AMSAT Newsletter. CW is to be found in the low frequency (third) part of the downlink passband, SSB in the high frequency (third) side, and mixed mode QSOs take place in the middle (third) of the passband.

Satellite	Mode	Uplink	Downlink
RS-10	A	145.860-145.900	29.360-29.400
	T	21.160-21.200	145.860-145.900
	K	21.160-21.200	29.360-29.400
	ROBOT	145.820	29.403
	ROBOT	21.120	29.403
	BEACONS		29.357, 29.403, 145.857, 145.903
RS-11	A	145.910-145.950	29.410-29.450
	T	21.210-21.250	145.910-145.950
	K	21.210-21.250	29.410-29.450
	ROBOT	145.830	29.453
	ROBOT	21.130	29.453
	BEACONS		29.407, 29.453, 145.907, 145.953

AMSAT-OSCAR 10 B	BEACON	435.050-435.155	145.955-145.850
AMSAT-OSCAR 10 B	BEACON		145.810
UOSAT-OSCAR 9 BEACON	BEACON		145.825 FM
UOSAT-OSCAR 11 BEACON	BEACON		145.826 FM
FUJI-OSCAR 12 JA	BEACON	145.900-146.000	435.900-435.800
JA	BEACON		435.797
JD	BEACON	145.850	435.910
		145.870	435.910
		145.890	435.910
		145.910	435.910

AMSAT-OSCAR 13 B	BEACON	435.420-435.570	145.975-145.825
L	BEACON		145.812
J	BEACON	1269.620-1269.330	435.715-436.005
RUDAK	BEACON	144.425-144.475	435.990-435.940
S	BEACON	1269.710	435.651
BEACON	BEACON	435.601-435.637	435.677
			2400.711-2400.747
			2400.325

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